SAE Journal

IN THIS ISSUE . . .

SAE ANNUAL MEETING stresses creativity in engineering 17

PUTTING ATOMIC ENERGY to work in the automotive industry 18

HOW MICROJET controls jet engines at high speeds ..21

ALLISON T56 TURBOPROP features flexibility 23

FUEL INJECTION for gasoline automobiles, Part II 27

GET UP TO DATE on automatic transmissions 36

Table of contents on page 15

FEBRUARY 1956

Published by The Society of Automotive Engineers

Type "98" oil ring—U. S. patent numbers 2,635,022 and 2,695,825

DESIGNED FOR DUTY!

Perfect Circle's top compression ring was specially designed to perform where pressures are greatest, heat is highest, and lubrication poorest. The new Type "98" oil ring with self-expanding spacer assures a uniform seal against the cylinder wall plus a side sealing action on the ring groove. Both the top compression rings and the oil rings are plated with thick, solid chrome that resists wear, more than doubles the life of cylinders, pistons and rings—means thousands of extra miles of sustained power with positive oil control. Perfect Circle Corporation, Hagerstown, Indiana; The Perfect Circle Co., Ltd., Toronto, Ontario.

PERFECT CIRCLE

chrome piston rings

THE STANDARD OF COMPARISON

FACTS

about

NEW DEPARTURE

BALL BEARINGS

Another "NEW DEPARTURE"!
Pocket-size calculator calculated to cut costs!

Prices at your finger tips for over 100,000 different bearings! This "new departure" in the bearing industry lists basic engineering data, simplifies ball bearing selection, helps engineers figure design costs.

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NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

Douglas announces opportunities for **MISSILES ENGINEERS** at Santa Monica

This is your invitation to join the nation's most experienced team of missiles engineers with 14 years' background in successful design and construction of missiles for the armed forces.

Enlarging previous activities, a new and independent Missiles Engineering Department adjacent to Missiles Manufacturing has recently been set up at Douglas in view of the increasing importance of missiles in the nation's defense. This new department looks ahead to rapidly expanding growth in a challenging field.

For engineers who like "frontier" work in creative design, this new Douglas department will have unusual appeal — with no ceiling on advancement.

To look into the immediate and the long range advantages this opportunity offers you, contact E. C. Kaliher, Engineering Personnel Manager, Missiles; Douglas Aircraft Company, Santa Monica, California.

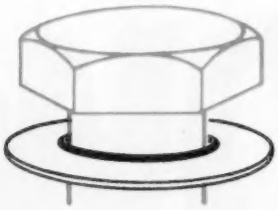
8 long-term projects

Now in progress at Douglas are 8 major missiles projects under contracts from the Air Force, Army and Navy. Among them are 3 missiles now in production — Honest John (above), Nike and Sparrow 1.

Missiles by *DOUGLAS* **First in Aviation**

SAE JOURNAL, February, 1956, Vol. 64, No. 3. Published monthly except two issues in January by the Society of Automotive Engineers, Inc. Publication office, at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 29 West 39th Street, New York 18, N. Y. $1 per number; $10 per year; foreign $12 per year; to members 50 cents per number, $5 per year. Entered as second class matter, September 15, 1948, at the Post Office at Lancaster, Pa., under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1948. Additional entry at New York, N. Y.

end leakage...have lock washer action with Precision O Dyna-seals



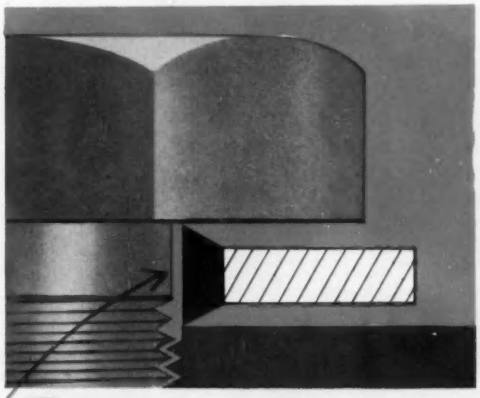
Seal up to 10,000 psi steady or pulsating pressure

Here is today's answer to leakage problems created by face-to-face sealing. Dyna-seals not only completely eliminate leakage but make possible important reductions in tooling, installation and maintenance costs.

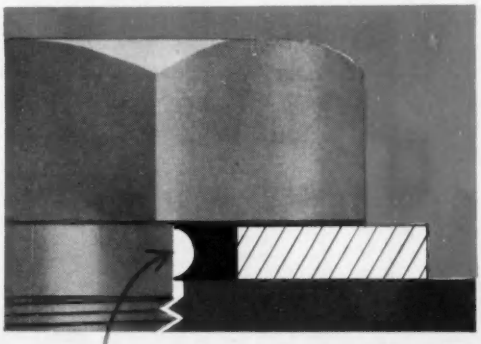
The secret of Dyna-seal success is a synthetic rubber sealing member, heat and pressure bonded to a steel washer. It supplies a positive lock washer action and reduces bolting torque. Under pressure, the flexing action of Dyna-seal assures a positive seal under all conditions—against water, gasses, petroleum products and many other fluids.

Dyna-seals permit face-to-face sealing with no grooves to cut or special machining of surface to be sealed. Here is simplicity in assembly that reduces fabrication costs and improves product appearance as well.

Use Dyna-seals on any flat surface under bolt or rivet heads, cap nuts, flanges, special fittings, etc. Let a Precision engineer work with you and demonstrate the advantages of putting Dyna-seals into your products.



Note flare of rubber sealing member. When compressed under any type of bolt, flange or screw, it provides positive lock washer action, and reduces bolting torque.



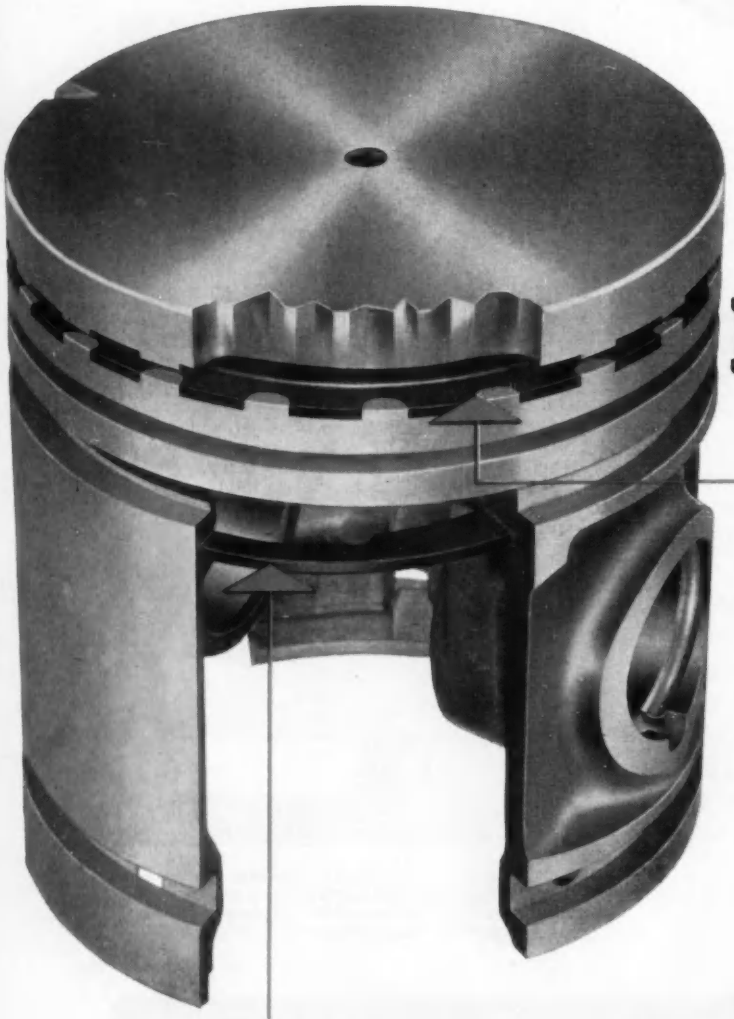
When pressure of bolt head is applied, sealing lips are forced against surface, forming a convex shape opposing steady or pulsating pressure. Dyna-seal provides positive sealing against leakage.

Precision Rubber Products CORPORATION

"O" Ring and Dyna-seal Specialists

3110 Oakridge Drive, Dayton 7, Ohio Canadian Plant at: Ste. Thérèse de Blainville, Québec

NOW! STERLING CONFORMATIC* PISTONS



CONFORMATIC STEEL CONTROL MEMBER, anchored at the pin bosses only, controls skirt clearance . . . hot or cold! The metered steel insert allows you to specify the piston clearance you want for your engine. (Clearances from zero to ½ thousandth inch are generally recommended.)

are available with LOW COST Intra-Cast* STEEL-LINED GROOVES

***Steel protection—top and bottom*—gives sensationally longer life to rings and grooves.**

This ring is *integrally cast* into the piston . . . positioned so that when the grooves are machined, the top ring groove is *lined with steel* and has islands of aluminum for ring cooling. This Intra-Cast steel-protected groove resists enlargement and materially reduces top ring land wear and rounding. And, it does it at far less cost than other methods.

** Tradename Registered*

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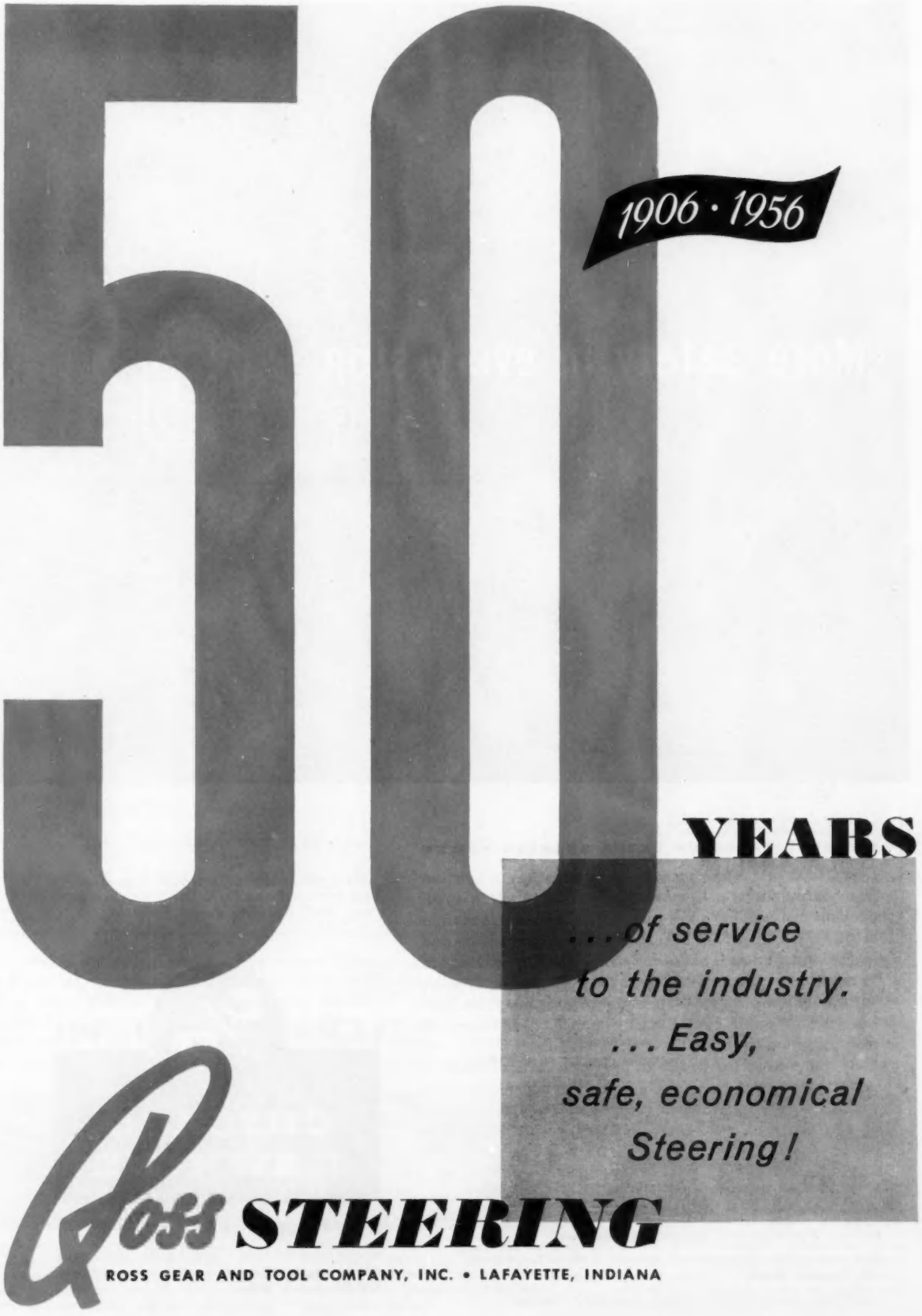
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1906 · 1956
YEARS
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to the industry.
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safe, economical
Steering!
Ross STEERING
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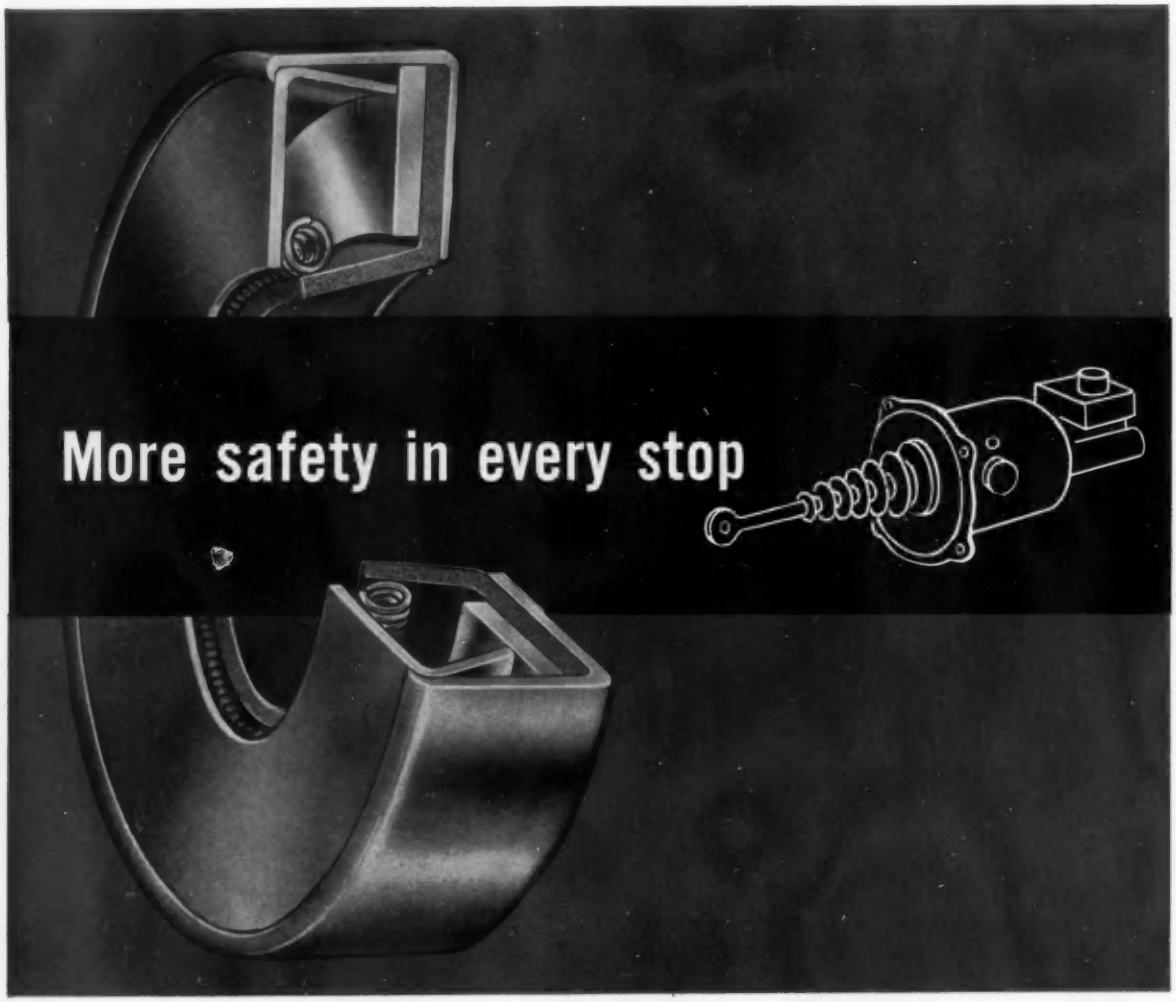


C/R SEAL BACKS UP EXTRA BRAKING POWER

Every time you touch your brake pedal it must function dependably. In a well-known power brake unit a small back-up seal is doing a big job—providing an extra margin of safety. It's a C/R Oil Seal used between the vacuum and hydraulic cylinders. The sealing element had to be designed to exacting requirements. It seals effectively on both sides, withstands pressures to 10 psi, and provides maximum flexibility to follow possible eccentricity up to .025". In thousands of applications there has never been a failure.

If your product must conform to equally high standards of performance, consider C/R Oil Seals. You may choose from 17 stock types in over 1800 sizes, or work with C/R engineers on special designs. Write for detailed information.

CHICAGO RAWHIDE MANUFACTURING COMPANY
1243 Elston Avenue • Chicago 22, Illinois

Offices in 55 principal cities. See your telephone book.

In Canada: Manufactured and Distributed by Super Oil Seal Mfg. Co., Ltd., Hamilton, Ontario

Export Sales: Geon International Corp., Great Neck, New York

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

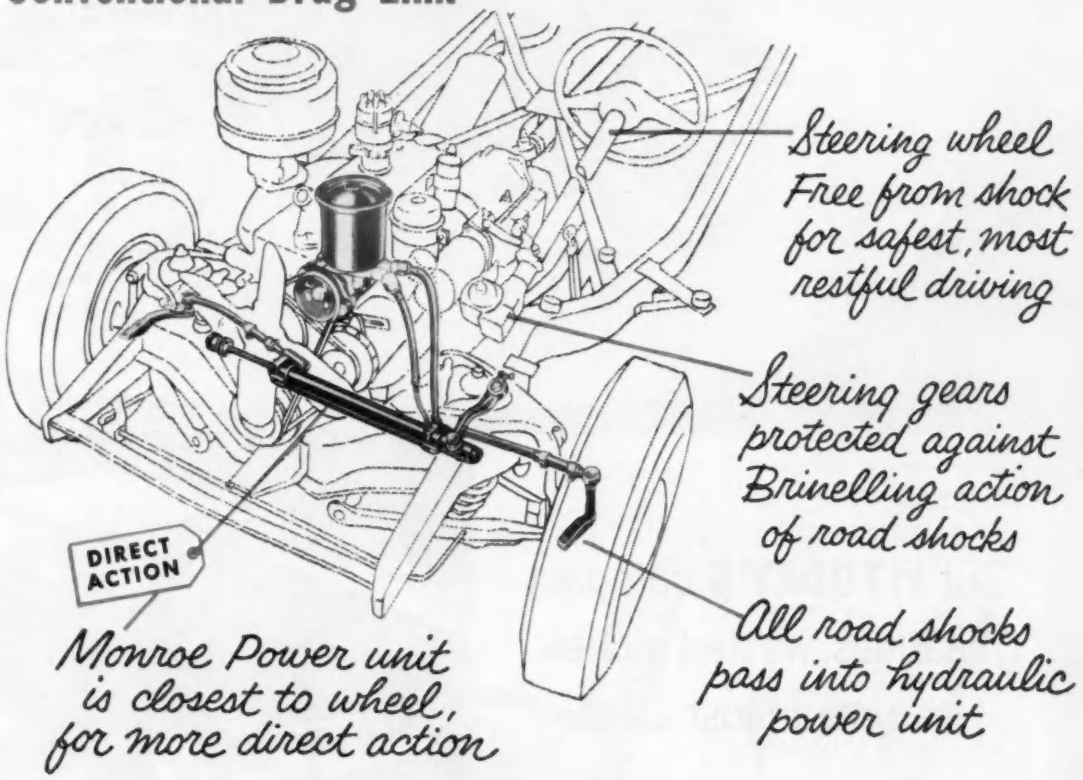
OIL SEAL C/R DIVISION
CHICAGO RAWHIDE

OTHER C/R PRODUCTS

Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

MONROE DIRECT ACTION POWER STEERING

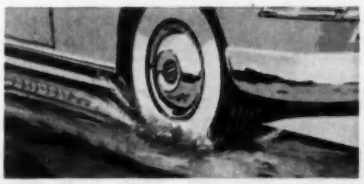
The only Truly Direct Action Design... Monroe Power Unit Replaces the Conventional Drag Link


Steering wheel Free from shock for safest, most restful driving
Steering gears protected against Brinelling action of road shocks
All road shocks pass into hydraulic power unit
DIRECT ACTION
Monroe Power unit is closest to wheel, for more direct action

Monroe is the only Direct Action Power Steering—as it is the only design where power unit replaces the drag link. Being Direct Action, and placed closest to the wheel, Monroe's hydraulic unit more completely absorbs road shock. Road shock can't reach the steering gears, so wear at this important point is reduced by as much as 70 to 80 percent. Brinelling is eliminated. No other system has so few parts, is so simple, or permits savings up to 20% by replacing the conventional drag link.

Our engineers will be glad to work with you on your Power Steering problems.

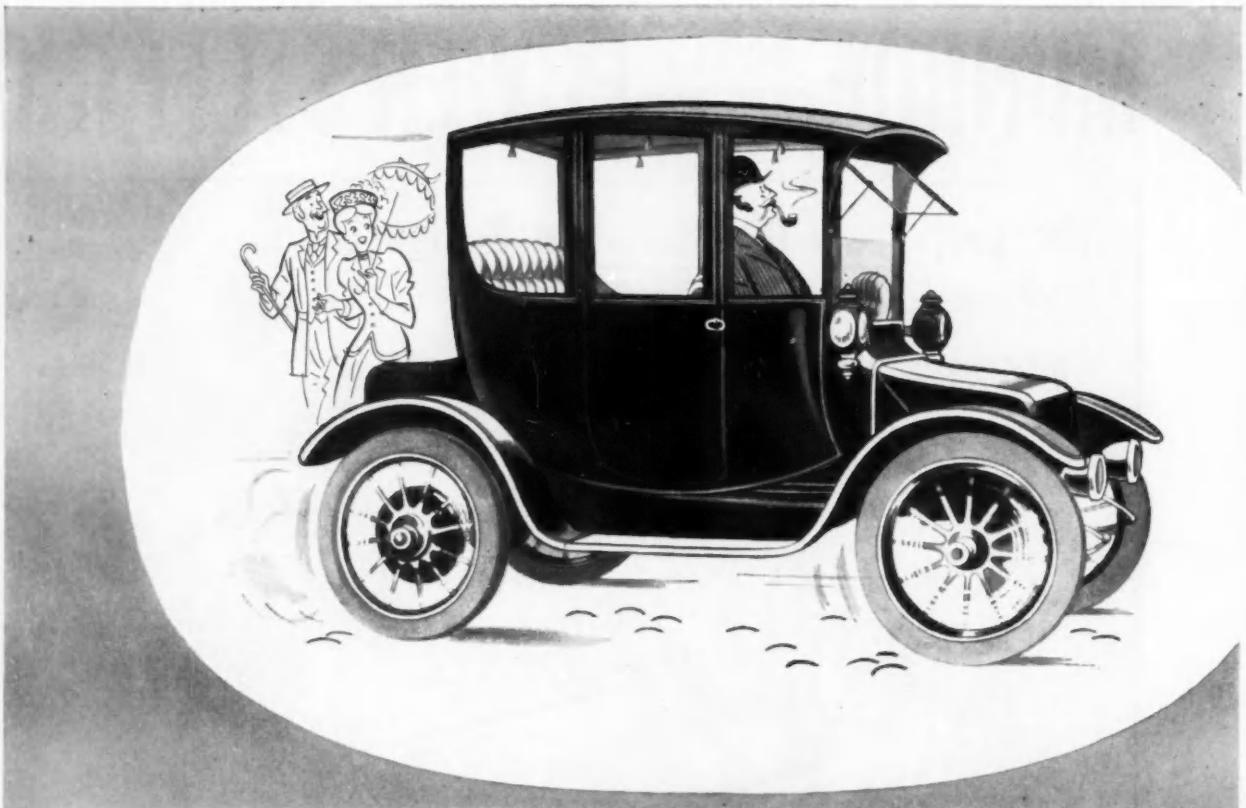
MONROE AUTO EQUIPMENT COMPANY, Monroe, Michigan



GREATER SAFETY—The firm, positive control of Monroe Direct Action Power Steering, eliminates much of the danger of dropping off pavement into soft shoulders, blowouts, flooded pavements, panic stops and such emergencies.

EFFORTLESS PARKING—Because Monroe Direct Action Power Steering takes practically all of the strain and effort out of parking, dealers find that sales of cars equipped with this device are much easier to make.

EASIER DRIVING—Monroe Direct Action Power Steering absorbs road shock before it reaches steering wheel. This, plus the removal of strain and effort of steering, leaves the driver fresh and relaxed after hours of driving.



But in **TODAY'S** compact beauties, wasted inches can mean lost sales

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THE WORLD'S FINEST, MOST MODERN CUSHIONING

Airfoam—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

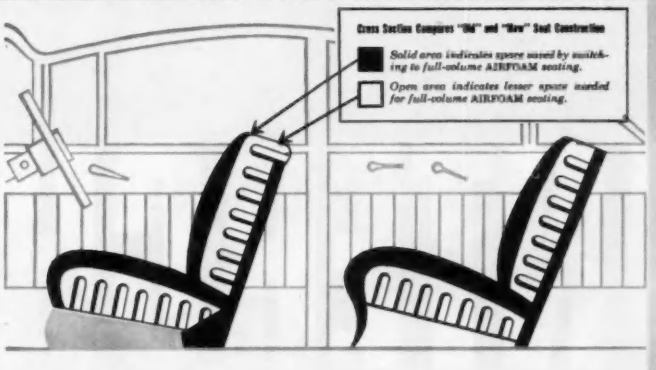
When the Argo Electric had a windshield two feet high–

who cared how high they piled the SEATING?

How **AIRFOAM** creates sales by creating

R-O-O-M

FOR COMFORT


Cross Section Compares "Old" and "New" Seat Construction
Solid area indicates space saved by switching to full-volume AIRFOAM seating.
Open area indicates lesser space needed for full-volume AIRFOAM seating.

AIRFOAM makes interiors roomier, more luxurious

Exciting new seating ideas become practical with **AIRFOAM**

Premolded **AIRFOAM** replaces expensive handwork — looks even richer

AIRFOAM can be your greatest sales-aid in years

GREAT THINGS ARE HAPPENING to automotive interior design. They are unprecedented things, things that confound old-time upholsterers, things that give the car-shopping public more room – and more reason – to reach for their checkbooks.

WORKING WITH FOREMOST AUTOMOBILE MAKERS and designers, AIRFOAM Development Engineers are fast outdating old-way bulky assemblies. The new way achieves more glamorous, more comfortable seating that, seemingly magically, makes MORE ROOM FOR PEOPLE!

THESE NEW AIRFOAM SEAT-UNITS are helping boost sales in some of today's smartest lines. If you're interested in significant case histories, contact:

Goodyear, Automotive Products Dept., Akron 16, Ohio

Now a new TDA® lightweight tandem that features . . .

UNEQUALED PARTS INTERCHANGE-ABILITY

Uses many standard parts for faster service ...new lightweight design gives 7500 extra ton-miles of payload a year*

Longer service, simpler maintenance! Most wearing parts used in this new tandem are identical to parts in widely used Timken-Detroit® standard single axles. This use of standard gears, pinions, differentials, bearings and brakes means more time on the road for operators . . . reduces parts inventories . . . and speeds service.

7500 extra ton-miles of payload a year! This new TDA tandem is over two hundred pounds lighter than any other unit of the same capacity. During an average 75,000 mile year, an operator can save 7500 deadweight ton-miles. This deadweight can be replaced with vital payload that adds up to important extra profit.

Available with a choice of either Timken-Detroit Axle connecting groups, or brackets to accept other approved chassis hook-up parts . . . plus all these additional advantages with the Timken® lightweight tandem:

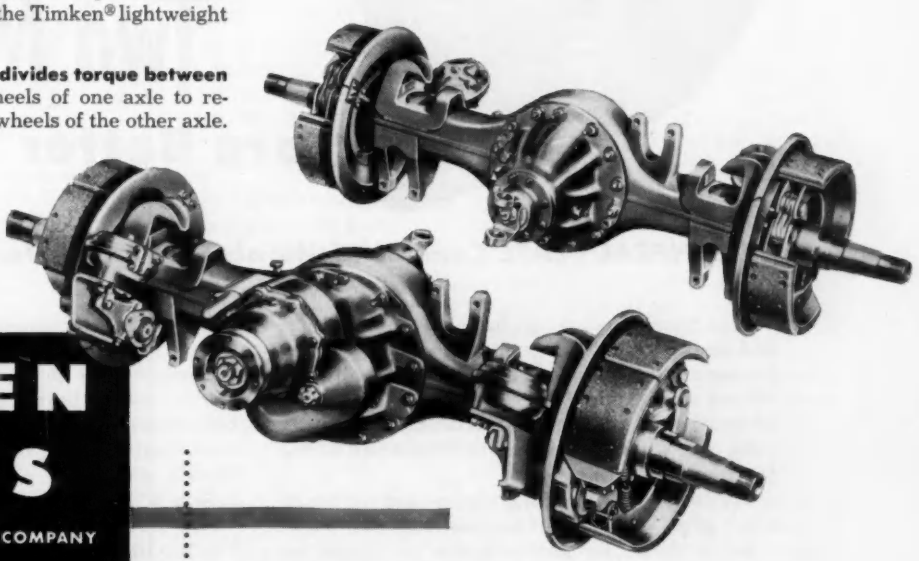
TDA Inter-Axle Differential divides torque between axles—and yet permits wheels of one axle to revolve faster or slower than wheels of the other axle. This means both axles are always doing equal amounts of work—driving parts and tires last longer!

Driver-Controlled Lockout. With TDA inter-axle differential, the driver can obtain the advantage of straight-through drive under slick or icy conditions by locking out the differential at *any* driving speed.

Big, dependable hypoid gears rotate in conventional direction, for maximum gear and bearing life.

This new highway tandem insures new payload profits, faster, easier service and operating economies for truck operators everywhere. For complete information contact your vehicle dealer or branch.

*based on 75,000 highway miles a year.



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Virgin metals and alloys have their limitations, and to overcome them . . . to get the *exact* performance you want . . . General Plate Composite Metals are the answer. They give you broadened physical and metallurgical characteristics . . . meet your specific requirements closer and do the job better, at lower costs.

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1102 FOREST STREET, ATTLEBORO, MASS.

For the Sake of Argument

Patience—Virtue or Vice?

By Norman G. Shidle

Is patience a virtue or a vice? . . . How about impatience?

Chances are the same answer will do for both: It depends on what the patience or impatience is being applied to—and when and why.

When being patient is simply an unreasoning acceptance of whatever does or does not happen, it can easily become a vice. When impatience is unreasoned irritation about the same things it already *is* a vice.

To be a virtue, either of these opposite qualities must have an objective, something to be accomplished by its exercise. If somebody hadn't been impatient with good things as they were, things would never be as good as they are. . . . And if someone hadn't been patient with failure, few of the world's successes would have been achieved.

As some slang-ridden "philosopher" wrote one time: "Patience with good . . . that's not bad. But patience with bad . . . that's not good."

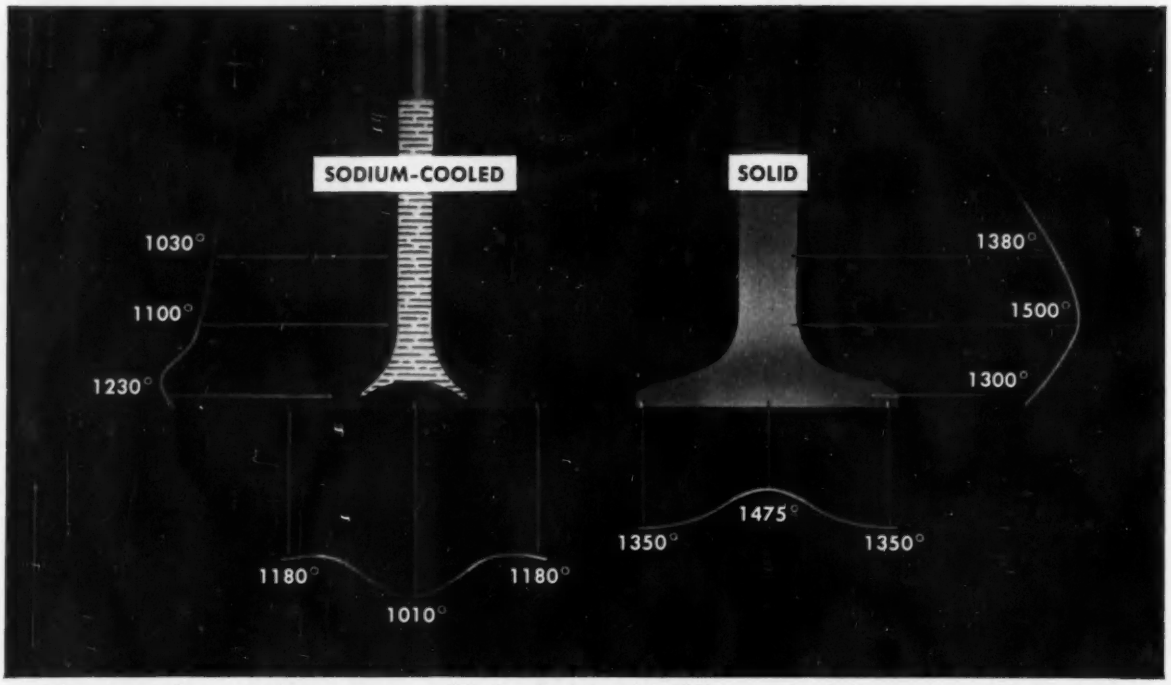
Then there's the question of timing to think about. We know one chap who is always impatient to get started—on a trip or a project or in preparation for an event. His theory is that if you hurry to get started, you will have time to proceed with care. If you're slow to start, you are more likely to *have* to hurry to finish in time. "Get started early—then relax and drive smoothly," is the way he summarizes. "That way, you're only under pressure for a few minutes, instead of all day."

Then there's another fellow who not only gets started in a hurry, but drives as fast as he can to arrive as far ahead of time as possible. "That way," he reasons, "I get three things done as compared to maybe one otherwise." He's right about it, too, as regards himself. . . .

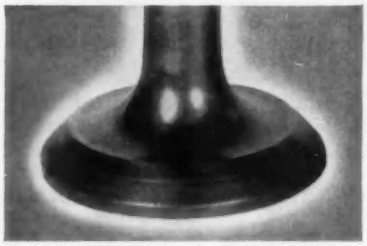
Dangers, though, do exist. Only a few can keep pressing and stay accurate. Only a few have mental and physical capacity for continuous enthusiasm and attack. Group pace determines the speed of accomplishment in most modern industry projects.

Both patience and impatience when they turn out to be "healthy" are likely to be on the virtuous side.

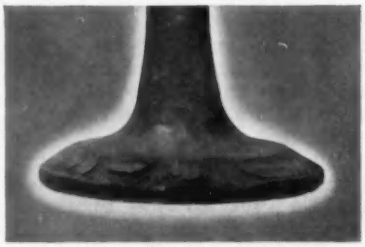
Eaton Sodium-Cooled Valves Run Cooler—



These curves show operating temperatures of Sodium-Cooled and Solid Valves under similar conditions of high output.



Eaton Sodium-Cooled Valve after 110,000 miles—still in good condition.



Conventional valve after 35,000 miles in same type of operation as Sodium-Cooled Valve shown above.

Cooler Valves Last Longer

Today's trend in engine design toward higher speeds and more economical fuel-air ratios results in higher temperatures for many operating parts—including exhaust valves. These higher temperatures sharply reduce valve resistance to corrosion and distortion, definitely limiting valve life. Eaton Sodium-Cooled Valves, operating at considerably lower temperatures, maintain corrosion resistance and strength.

In general, maintenance of Eaton Sodium-Cooled Valves in heavy-duty truck engines is scheduled only at time of major engine overhaul. No in-between trips to the shop are necessary for valve servicing. Engine output is maintained at high levels over long mileages. In many millions of miles of heavy-duty operation, Eaton Sodium-Cooled Valves have proven their ability to keep trucks on the road and out of the shop.

Eaton engineers will be glad to work with you in applying the benefits of Sodium-Cooled Valves to your engines.

EATON

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PRODUCTS: Sodium Cooled, Poppet, and Free Valves * Tappets * Hydraulic Valve Lifters * Valve Seat Inserts * Jet Engine Parts * Rotor Pumps * Motor Truck Axles * Permanent Mold Gray Iron Castings * Heater-Defroster Units * Snap Rings Springtites * Spring Washers * Cold Drawn Steel * Stampings * Leaf and Coil Springs * Dynamatic Drives, Brakes, Dynamometers

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Contents—February, 1956

Report of 1956 SAE Annual Meeting 17

Atomic Energy Opens New Horizons for Industry—New Problems Too!—Report by A. J. POMEROY 18

Chassis Dynamometer—P. E. MIZELLE, J. C. PORTER and A. R. RESCORLA 20

Microjet . . . pneumatically controls jet engines—W. E. REED 21

Allison T56 Turboprop Features Flexibility—JOHN B. WHEATLEY, D. G. ZIMMERMAN and R. W. HICKS 23

Fuel Injection for Gasoline Automobiles—Part II—S. E. MILLER, ALEX HOSSACK 27

American Automatic Transmissions—S. E. SWALLOW 36

What's New About the 1956 Hydra-Matic—KENNETH W. GAGE and P. J. RHOADS 42

What's New About the 1956 Dynaflow—R. J. GORSKY 50

Twin Ultramatic Transmission—C. J. LUCIA and J. Z. DeLOREAN 57

Lincoln Turbo Drive Transmission—H. G. ENGLISH 60

All Wheel Drives—H. C. McCASLIN, G. W. SCHARBACK 62

The Powermatic—H. O. FLYNN 63

The Allison TC-12 Torqmatic Transmission—R. C. WILLIAMS, H. C. KIRTLAND and C. M. JORDAN 67

Euclid's TC-12 Twin Crawler Tractor—R. C. WILLIAMS 71

Euclid Twin Tractor Styling—C. M. JORDAN 72

Creative Engineering: Path to Progress (Story of Annual Meeting) 74

■

About SAE Members 94

SAE Section News 97

News of SAE 103

1956 SAE National Passenger Car, Body, and Materials Meeting Announcement 104

1956 National Meetings Schedule 104

Technical Digests 108

New Members Qualified 127

Applications Received 130

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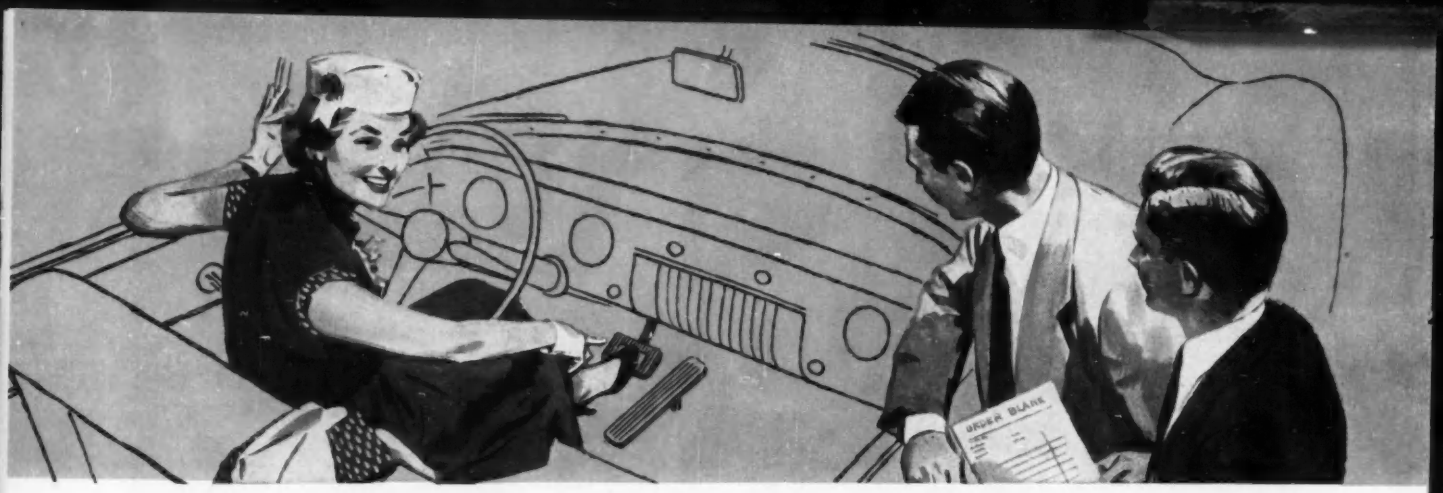

BENDIX POWER BRAKES ARE A PERFORMANCE-PROVEN SALES FEATURE

Bendix POWER BRAKES

First in the field - now standard of the industry!

The first practical power brake to be put on the market was developed and produced by Bendix. Today Bendix* Power Brakes are specified by practically every car manufacturer in the industry.

This industry-wide acceptance of the most revolutionary development in braking since Bendix four-wheel brakes is convincing evidence of Bendix foresight in research and engineering. And the fact that today more Bendix Power Brakes are in use than all other makes combined demonstrates conclusively the ability of Bendix to *produce* as well as to *plan ahead* for the industry's requirements.

Available in low pedal or high pedal designs to meet individual manufacturers' requirements, Bendix Power Brakes are a potent source of customer good will from the first mile to trade-in time.

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1956 Annual Meeting Reflects

CREATIVE ENGINEERING

both in presentations and technical content

THE results of creative engineering were reflected in more than 60 papers and innumerable discussions at SAE's 1956 Annual Meeting.

Even greater-than-usual active participation by top engineers and engineering-minded executives marked the 25 technical sessions of this meeting with which the Society of Automotive Engineers began its second fifty years of technical progress. The principal speaker at the banquet was a former chief executive of the State of Michigan. Secretary of the Army Wilber M. Brucker returned to deliver stimulating ideas to this gathering of his home state's most creative minds.

Presentations Attractive

Creative presentation of the many creative engineering ideas kept popping up here and there throughout the sessions. An unusual number of speakers had given special attention to the quality of their slides. Others had tailored their diction to easy-listening needs. More than a few put special audience-appeal features into their presentations in general.

And these extra author-efforts were appreciated. Throngs of listeners crowded most of the technical sessions.

Engineering Display Expands

The Engineering Display stretched its show space over all the room previously occupied on the Ball Room Floor of the Sheraton-Cadillac and down to the English Room on the First Mezzanine as well. Never before have more interesting units been displayed . . . and never before did more people visit the displays . . . this year sponsored by 113 exhibitors.

Technical sessions again were held at both the Sheraton-Cadillac and the Statler . . . and meeting rooms full of interested audiences greeted the speakers in both hotels.

An Unusual Session

The Production Activity-sponsored session on Tuesday was an outstanding event, both in the caliber of personnel participating—and in the presentation itself. (See p. 84.) It was styled "A Case

CONTINUED ON PAGE 83

TWO SAE PRESIDENTS seem equally happy about beginning and ending their terms as the Society's chief executive. At the left is George A. Delaney (1956); at right, C. G. A. Rosen (1955).

Atomic Energy Opens New Horizons

No longer can any segment of American industry or business afford to shrug off atomic energy as a military weapon or scientific playtoy. Nuclear powerplants for power generation are under construction, an atomic aircraft engine is promised within five years, and radioactive materials already are playing important roles in industrial research and production.

These are among the key points made by dozens of speakers and participants in NICB's Fourth Annual Atomic Energy Conference. Comments made by some of the participants in the Conference follow.

Nuclear Electric Power A Matter of Economics

Sir John Cockroft, head of England's Atomic Energy Research Establishment, said that at the end of this century, demands for electrical energy will be four to five times that of the present rate of consumption. Part of this increased demand will be met with nuclear power. In fact, said Cockroft, by 1975 there will be considerable nuclear-generated power. It will come first in places where there's no hydro power. Economics will dictate the speed with which it'll be introduced in other places.

England will need another million tons of coal by 1975. Right now British nuclear powerplants under construction will produce the equivalent in electricity of 40 million tons of coal annually.

The Russians at Geneva said that nuclear electricity should cost them 10–20 kopeks per kw as compared with 10 kopeks for coal.

British figures show that 150 megawatt nuclear reactors will produce power for about 9 mils. The cost should come down to about 7 mils by taking advantage of plutonium production from operating breeder reactors.

Cockroft predicted that by 1970, two type breeding reactors will become practical. A fast breeder type reactor should have a breeding factor of 1.6 or 1.7.

Waste product disposal is still a big problem. Aim today is to separate the long-life useful components and to store the other stuff. Experts figure that disposal of radioactive wastes will run 1 to 2% of the cost of the power.

Shielding the Bottleneck In Nuclear Transportation

Atomic engines look feasible for ships and railroads. They'll be powering airplanes in five to 10 years, although the problems are a little tougher. But unless the scientists break off a new hunk of knowledge that isn't foreseeable at present, nuclear-powered motor vehicles will remain confined to the Sunday supplement pages.

It's all wrapped up in the problem of shielding the radiation from nuclear reactions.

Dr. E. V. Blizard, of AEC at Oak Ridge, says shielding will have to attenuate by 12 to 15 factors of 10 to safeguard human beings.

Blizard said a reactor shield must do a two-way job:

1. Screen out neutrons. That calls for a hydrogenous material . . . water is pretty good.
2. Stop the gamma rays. This must be done by a dense material. Uranium is best, although lead can be effective.

The crux of the problem lies in the fact that there just aren't any elements better than uranium and water. But shields made of them are too bulky, too heavy for most vehicular applications. Arrangements of the materials in a shielding design may net some gain, but not much.

Here's a typical example of what you're up against in designing shielding for a reactor (by Lyle Borst, head of NYU's Physics Department):

Take a 2000 hp locomotive. To get the 2000 hp from the boilers, you'll need a reactor that operates at a power output of 1.4 megawatts and must produce 12.9 megawatts of heat. The reactor can be confined to a volume of 1.4 cu ft.

Borst selects a water-uranium shielding, containing 10% (by volume) of uranium. The shielding thickness will have to be 222 cm. The diameter of reactor and shielding will have to be 14.5 ft and the whole package will weigh 250,000 lb. The diameter

Report by **A. J. Pomeroy,**
SAE Special Adviser to the SAE President on Atomic Energy

for Industry

—New Problems Too!

is too great because most railroads have a clearance of 15 ft.

The diameter might be cut to 12 ft by increasing the shielding metal content from 10% to 50%, but the weight would go up.

So Prof. Borst concludes that possibilities of success with nuclear-powered locomotives are marginal.

The airplane looks like a better bet, said Dr. Lee Ohlinger, of Northrop Aircraft. He said companies like Pratt & Whitney and General Electric have prime contract on a nuclear aircraft engine. Extrapolating from past experience in aircraft engine development, he predicts that the first atomic-powered plane will be flight tested in 1958 or '59.

Ohlinger says that it'll take about 50 tons of shielding for a reactor to power an airplane. So nuclear power will be confined to very large airplanes. Disposition of the shielding will take some design ingenuity.

For instance, part of the shielding may be placed around the crew and part of it around the reactor. Or designers may go to a two-plane tandem arrangement, with the powerplant in one plane and the crew and cargo in another, remotely controlled.

In any event, engine location will be a problem, because of the high weight concentration, for one. Then, too, the crew and engine will have to be separated by a considerable distance. Since the plane will weigh about as much at landing as at take-off, landing gear designers will be faced with more stringent requirements.

Among the operating problems you face with atomic-powered planes are these:

1. How do you control the powerplant at shutdown? A nuclear reactor can't be shut down completely. It would generate power even when the airplane is not in use.
2. You can control the powerplant only for large changes in power needs.
3. Long runways will be needed for landing.
4. Protection will have to be worked out for the ground crew. Runway contamination is another problem.
5. In crash landing an atomic airplane, the crash area will be inacessible for a considerable period.
6. Nuclear powerplants do "poison" themselves. Techniques will have to be worked out for servicing and replacing nuclear engines.

Radioisotopes Put to Work On Broad Industrial Fronts

Radioisotopes are saving millions of dollars and doing jobs never before possible in many industries. That's what a panel of 10 industrial researchers and engineers reported. Here are just a few current radioisotope applications.

In the petroleum industry . . .

- In tracing underground migration, part of the process using repressuring gases to recover more oil from a well.
- Radioactive tagging of stored petroleum products.
- In mixing and blending products, such as greases. Isotope tracers tell when greases have been adequately mixed, save production time.
- Gamma-emitting isotopes play a part in cracking, coking, and fluid catalytic cracking.

In metallurgy . . .

- In machining studies to measure tool wear.
- To measure distribution of elements or compounds in a metal's structure.
- To determine the role of mercury in aluminum corrosion.
- In surface chemistry, to measure the true surface area of a flat sheet specimen.

In automotive research and development . . .

- For measuring coolant leakage around cylinder heads.

CONTINUED ON NEXT PAGE

CONTINUED FROM PAGE 19

- For checking oil seal leaks in tractors.
- For observing piston ring rotation around a piston.
- Used in a device for accurate measurement of air flow.
- In wear measurements—tires against concrete, wear of gears, bearings, and piston rings.

In the construction industry . . .

- Used to check welds. With a new gamma ray instrument, one man can now check welds about twice as fast as a five-man crew by conventional methods.

In the food industry . . .

- To evaluate and appraise food additives and processing chemicals.
- In food sterilization. (The Army Quartermaster is spending millions of dollars on this project and is eager to talk with anyone and ready to give research contracts. An experimental radioisotope sterilization plant for production processing of foods is a definite part of the Quartermaster program.) There has been considerable success in using radio pasteurization to increase milk storage periods. Irradiated potatoes have been stored for 18 months without sprouting and with no effect on their taste. Although radiation hasn't formed any toxic compounds in foods, it has produced off-color and off-taste effects in some foods and destroyed vitamins in others.

No Peaceful Uses in Sight For Thermonuclear Energy—Yet

About the only use for nuclear fusion today is the H-bomb. Scientists pointed out that non-weapons potential from thermonuclear energy is remote. Here's why:

To set off an H-bomb, you need to start with an A-bomb because it takes almost as much heat as is available on the sun to initiate the fusion reaction. So as one scientist put it: "To harness the energy from a fusion reaction, you don't have to worry about what kind of material it'll take to contain the process. In fact, all your problems evaporate!"

Chassis Dynamometer . . .

. . . has become satisfactory instrument for measuring octanes. It allows road ratings to be obtained in the lab at less time and cost.

Based on paper by **P. E. Mizelle, J. C. Porter, and A. R. Rescorla,** Cities Service Research & Development Co.

THREE years' experience indicates that the chassis dynamometer is an effective and accurate instrument for obtaining in the laboratory octane ratings comparable to those obtained on the road.

The experience of more than 12 petroleum companies indicates that using the Modified Borderline Procedure in conjunction with the chassis dynamometer (which is shown in action in Fig. 1) allows the evaluation of base stocks, experimental blends, and final gasolines with satisfactory precision.

In the past, reasonably satisfactory octane ratings were obtained with CFR single-cylinder laboratory engines. In recent years this has become less and less true, for the differences between road octane ratings obtained in a multicylinder engine and the values obtained with the single-cylinder lab engines have increased. This is especially true as regards performance in high-compression-ratio engines having improved high-speed volumetric efficiency. For example, a commercial premium-grade gasoline may have a rating of 93 octane at 2500 rpm in an engine of recent design and a Motor Method (F-2) laboratory rating of only 85.

Fig. 1—Test car on chassis dynamometer.

The Modified Borderline Procedure requires more time and personnel to rate a gasoline than do the F-1 and F-2 laboratory procedures. As a result it has not been feasible for a company to evaluate all its stocks and blends by this method. This is why the chassis dynamometer has become an important piece of equipment for the petroleum company laboratory.

Briefly, the advantages of the chassis dynamometer in obtaining road ratings are:

1. Less personnel can obtain more ratings in a given day.
2. By allowing ratings to be conducted indoors, weather and traffic problems are largely eliminated.
3. More nearly uniform conditions of atmosphere, vehicle load, and wind velocity are obtained.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Microjet . . .

. . . pneumatically controls jet engines

W. E. Reed, Solar Aircraft Co.

Based on paper "A New Approach to Turbojet and Ramjet Engine Control" presented at SAE Golden Anniversary Aeronautic Meeting, Los Angeles, Oct. 14, 1955.

THE Microjet Control makes it possible to use pressure ratios as the control parameter for gas turbine powerplants. The device is a new type of pneumatic computing control. Its design omits the bellows, springs, and complex linkages common to pneumatic controls. The result is greater reliability at high flight speeds.

Fig. 1 shows the operating principle of the Microjet Control. It provides a mechanical displacement output signal. This signal is a measure of the ratio of two pressures.

One pressure, ΣP_E, is applied to the upper side of a flexible diaphragm and the other, P_2, which generates a controlled reference pressure, to the lower side. The reference pressure is generated by bleeding air, generally from compressor discharge in jet engines, through a pair of orifices in series.

A tapered needle is attached at one end to the diaphragm. The other end of the needle extends into the area, a_2, of the second orifice. Movement of the diaphragm causes movement of the tapered needle which results in control of the orifice area.

The flexible diaphragm maintains the reference pressure exactly equal to the pressure on its upper side. As can be seen in Fig. 1, **decreasing** the upper-chamber pressure results in upward movement of the diaphragm causing a corresponding increase in the area of the second orifice.

This lowers the reference pressure and retards the movement of the diaphragm, until equilibrium is re-established, and the diaphragm has moved to a new position where the two pressures are equal. This position is directly related to the new value of the ratio between the two applied pressures.

As an example of this principle let us say that ΣP_E is 50 psi and P_1 is 100 psi. In the initial position shown by the solid diaphragm and tapered needle, part of P_1 bleeds out of orifice a_1 so that the P_2 acting on the bottom side of the diaphragm is momentarily—say, 75 psi. The unbalance of forces on the diaphragm cause the diaphragm to start moving up which, in turn, increases the flow area of a_2.

The diaphragm reaches an equilibrium point (the dotted diaphragm and needle) when 50 psi is acting on both sides of the diaphragm. At this point the position of the needle on the output (Y) scale gives the ratio of ΣP_E to P_1.

Of course, increasing ΣP_E has the opposite effect on the diaphragm and needle. It tends to depress them and decrease the area of a_2.

That sufficient pneumatic parameters are available to control the cycle of the turbojet engine is illustrated in Fig. 2. Engine matching characteristics can be controlled using three engine pressure ratios. If the rpm and two pressure ratios are known, the actual turbine inlet temperature can be controlled.

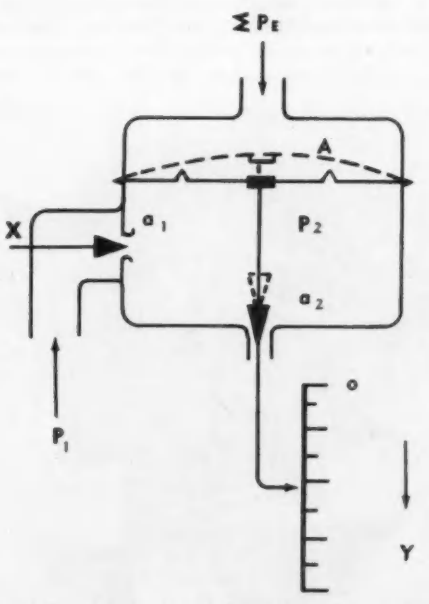


Fig. 1—Operating principle of the Microjet Control. Note the tapered needle which controls the area (a_2) of the second orifice and keeps the reference pressure equal to the pressure acting on the top side of the diaphragm.

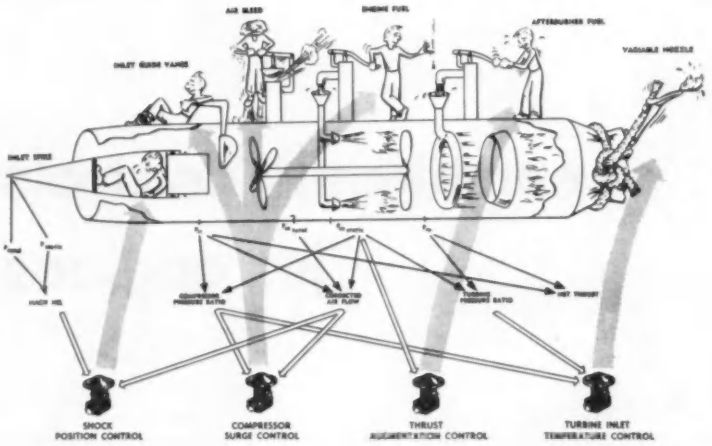


Fig. 2—Shown here are the various pneumatic parameters used in the control of a jet engine. The four controls pictured keep the engine within the mechanical and thermodynamic limits required for high performance.

It is possible by sensing pressure ratio parameters in a jet engine to control the following:

1. Variable jet nozzle area
2. Afterburner fuel flow
3. Engine fuel flow
4. Compressor air bleed
5. Variable inlet guide vane angle
6. Variable inlet geometry

This maintains engine variables within the prescribed mechanical and thermodynamic limits required of a high performance engine.

Three basic equations define the steady state characteristics of the Microjet: the force balance equation, which states in effect that the sum of all forces acting on the diaphragm and needle assembly as a free body equals zero; the orifice flow equation, which states that the weight flow through the second orifice is equal to the flow through the first orifice; and an equation for the needle contour, which establishes the characteristics of the output displacement signal.

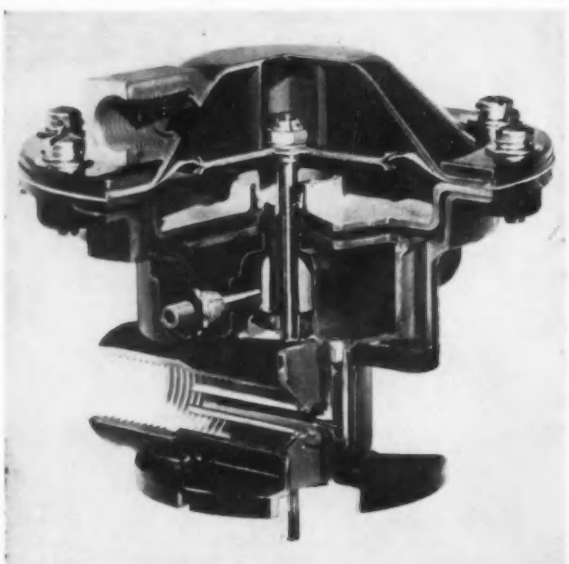


Fig. 3—Cutaway of the Microjet Control. Note the simple, sturdy construction and absence of springs and wearing parts.

Consideration of these three basic equations leads to the formulation of the following general equation describing the Microjet principle:

$$Y = f\left[f_X(X) \cdot f_N\left(\frac{\Sigma P_E}{P_1}\right)\right]$$

This equation states in effect that the output displacement (Y) is a function of the product of the pressure ratio function, $f(\Sigma P_E/P_1)$, and the input displacement function, $f_X(X)$. In this general equation, the terms $f_X(X)$, and $f(\Sigma P_E)$ are not specifically defined. They are general terms for which specific values may be selected according to the requirements of the application.

Almost any type of characteristic equation involving pressure ratios as parameters can be solved by substituting the appropriate values for the terms in the general equation. By using various types of mechanical inputs, such as throttle position or the displacement from some pressure or speed sensing device, the Microjet Control can be used to perform many sensing and computing functions.

Additional computing functions can be achieved by applying various types of forces to the movable element. These forces may include pressures acting on diaphragms or pistons, spring forces, or inertia forces. By these methods, various types of linear and non-linear schedules may be obtained and various pressure ratio parameters combined.

Although variations of the basic Microjet, such as the use of two diaphragms or the compounding of two Microjet units, are required to control some of the above factors, the principle remains the same.

The Microjet Control is relatively simple in construction. It uses a single non-resilient diaphragm, the size of which is not critical. It has no springs and is essentially friction-free, since it has no wearing parts. Because the needle extends through the second orifice to the region of ambient pressure the need for a precision, low friction seal is eliminated. The character of the construction is apparent from the cutaway shown in Fig. 3.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Allison T56 Turboprop Features Flexibility

John B. Wheatley, D. G. Zimmerman, and R. W. Hicks,
Allison Division, General Motors Corp.

Excerpts from paper, "The Allison T56 Turboprop Aircraft Engine," presented at the SAE Golden Anniversary Aeronautic Meeting, New York City, April 18, 1955.

THE Allison T56 turboprop aircraft engine has been designed to provide the user with unusual flexibility. He can have the propeller shaft offset upward or downward, and he can have the engine accessories installed on either the bottom or the top of the power section.

Engine Design

The engine (Fig. 1) is so designed that all aircraft accessories are mounted on the reduction gear rear case, in a volume made available by the need for an efficient inlet air duct curving into the front face of the power section after passing outside the reduction gear. This arrangement of engine favors frontal area at the expense of overall length, and results in a nacelle of good fineness ratio which has extremely low drag. Serviceability is enhanced by the ability to stock spare subassemblies and replace them at separately established, and different, authorized overhaul times.

The T56 engine weighs 1600 lb and delivers 3460

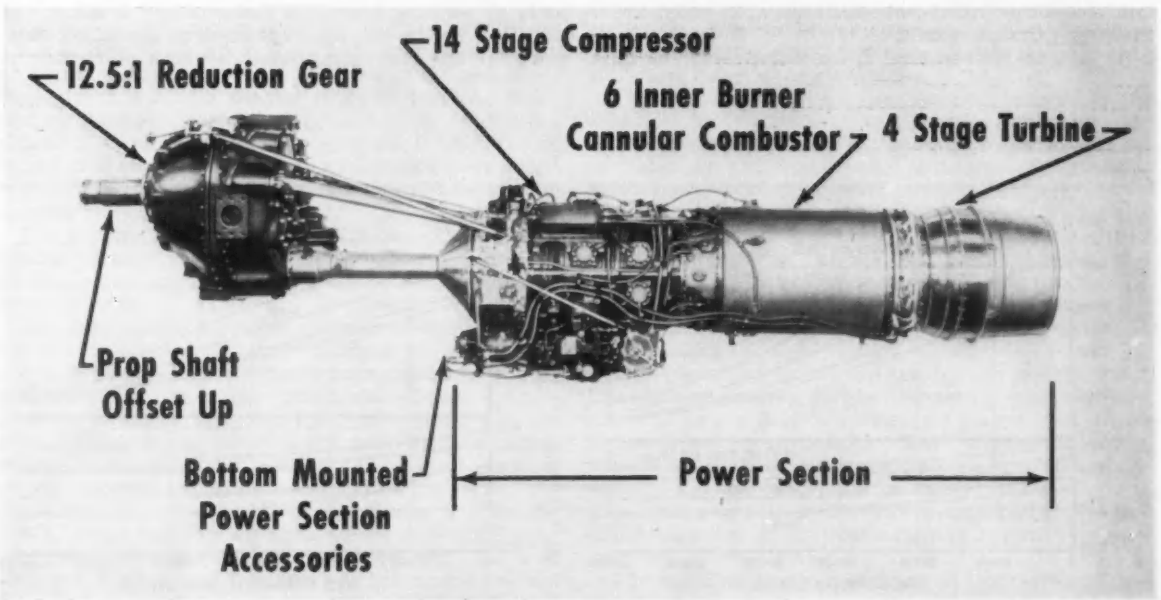


Fig. 1—Allison T56 turboprop aircraft engine has propeller shaft that can be offset upward (as shown here) or downward and engine accessories can be installed on either bottom (as shown here) or top of power section.

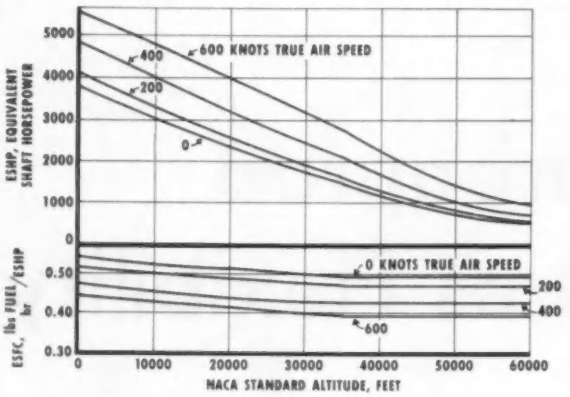


Fig. 2—Performance of T56-A-1 engine—military power.

shaft hp and 725 lb jet thrust at 13,800 rpm (equivalent to 3750 hp) at take-off and military power. The engine weight per horsepower is 0.43 lb per ehp when using JP-4 fuel. Performance under altitude conditions at various flight speeds is shown in Figs. 2–4. The wide variation in output and specific fuel consumption as a function of altitude and flight speed is apparent, illustrating the difficulty of describing or comparing engines except at specific conditions.

Power Section Assembly

The power section consists of a 14-stage axial-flow compressor, 6 cylindrical through-flow combustion liners within a cannular combustion chamber, and a 4-stage axial-flow turbine with fixed-area, integral exhaust nozzle.

As can be seen in Fig. 5, the compressor-turbine rotor system is designed around a 4-bearing arrangement with both rotors being straddle mounted and connected by flexible splined couplings and a torque shaft. A single locating thrust bearing is employed at the aft compressor location. The compressor rotor end thrust is opposed by the turbine rotor thrust through a connecting tie-bolt; any residual thrust, which varies with operating conditions, being within the thrust capacity of the rear compressor bearing. This method of rotor thrust balance eliminates the requirement for large-diameter, high-pressure-drop air seals and consequently reduces air leakage losses.

With the exception of the air inlet housing and accessories housing, which are magnesium-alloy castings, the remainder of the power section is constructed entirely of steel. This, coupled with employing the outer combustion-chamber shell as a structural load-carrying member, has resulted in a power section assembly of great ruggedness and minimum weight.

The compressor assembly, consisting of the air inlet housing, compressor rotor, stator assemblies within the compressor housing, and the diffuser assembly embodies some unique features. Some of these, which differ from usual industry-wide practice, seem worthy of particular mention.

The rotor employs stiff end wheels and a single, center tie-bolt for axial clamping. Centering of and transmission of torque through the intervening wheels is taken through splines joining the adjacent wheel rims and spacers. This method of construction results in maximum utilization of material and a high degree of rotor rigidity and stability. The blades are pinned in dovetail slots in the wheel rims.

The compressor housing is of 2-piece, longitudinally split, welded construction with stator vanes and rings bolted in each half. Provisions are made for mounting automatically operated starting air bleed valves at the fifth- and tenth-stage locations.

The diffuser assembly is fabricated of stainless steel by welding and high-temperature brazing. In addition to the normal functions of providing support for the rear compressor bearing and efficient

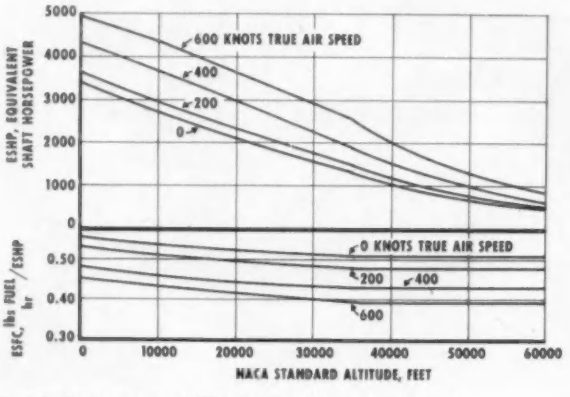


Fig. 3—Performance of T56-A-1 engine—normal power.

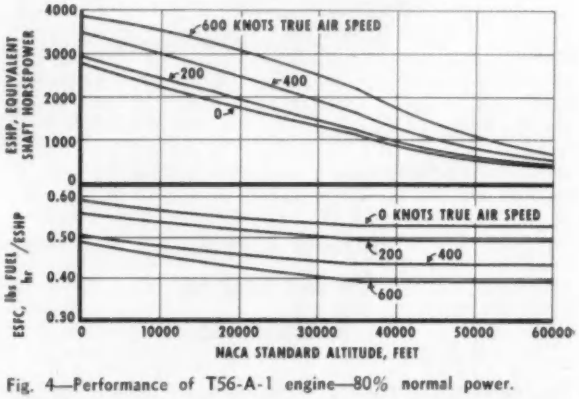


Fig. 4—Performance of T56-A-1 engine—80% normal power.

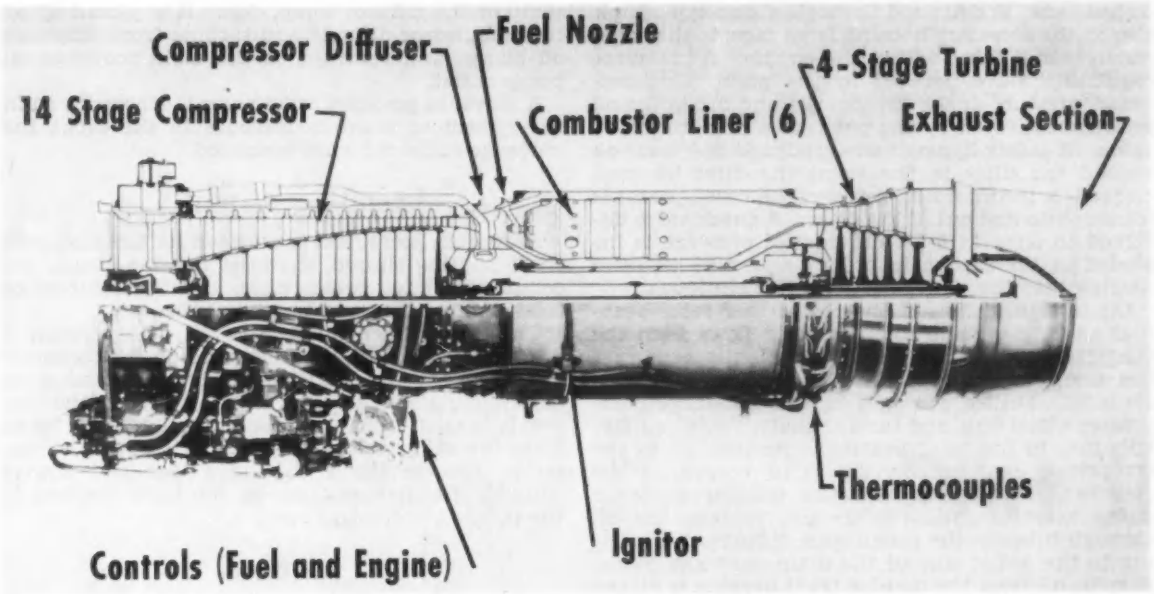


Fig. 5—Power section assembly of T56-A-1 engine.

diffusion of compressor discharge air for combustion, uncontaminated bleed air at compressor discharge pressure for cabin conditioning and other uses is provided at three discharge ports having quick-disconnect flange connections. The diffuser flanges also provide attachment for the engine rear mount. At this location also is the engine fire shield which isolates the hot portion of the power section from the fuel system.

The combustion-chamber assembly is composed of six combustion liners encircling a combustion-chamber inner casing and contained within an outer casing. The liners are of through-flow design and are positioned at the outlet end by the first-stage turbine nozzle shroud rings and at the front end by the fuel nozzles and igniter plugs or dummy plugs. The outer combustion chamber is a one-piece cylindrical steel shell and, as mentioned previously, is a main structural member supporting the turbine assembly.

The turbine assembly consists of the turbine inlet casing, turbine vane casings, and stator assemblies, turbine rotor and rear bearing support with integral exhaust nozzle.

The four stages of turbine wheels and intermediate spacer discs are spline mounted on a common shaft, all of these details being machined from heat-resistant stainless steel. The turbine blades in the first three stages are precision-cast GMR-235, an alloy having high-temperature properties superior to any known material suitable for blading use, and at the same time having a low critical material index number. The fourth-stage blades are forged S-816, being used in an area where superior high-temperature properties are not required. All four stages of blading are loosely fit to the turbine wheel rims in broached serrations of 5-tooth fir-tree design. The blades are restrained axially by the rotor spacer discs, and by wheel rim lugs on the No. 1 and No. 4 wheels.

The turbine vanes or stators (also GMR-235 precision castings) are welded to inner and outer shroud rings and installed in six segments per stage within the turbine vane casings. The inner rings form interstage labyrinth seals with rotating knife edges on the rotor spacer discs. It will be noted that, with the exception of the fourth stage, extensions of the outer shroud rings together with the turbine casings form, in effect, a double-walled construction. This arrangement greatly minimizes distortion of the casings and appreciably reduces surrounding nacelle temperatures.

The rear turbine bearing support assembly, in addition to functioning as its name indicates, defines an efficient diffusion passage for the exhaust gas and so establishes the optimum jet thrust—shaft power split for maximum total output.

A concerted effort has been made throughout the power section to keep the critical material index low, particularly in the use of cobalt, tungsten, and columbium. The ability to use GMR-235 for turbine vanes and blades has materially lowered the index in that none of these critical elements are contained in that alloy.

The power section incorporates an independent dry sump oil system which includes one combination main pressure and scavenge oil pump and three separate scavenge pumps. This system, however, can be connected to a common supply with the reduction gear assembly, as the same type of oil (that conforming to MIL-L-7808) is used in both. A schematic diagram of the power section system is shown in Fig. 6.

The main oil pump is located on the center of the front face of the accessory drive housing. Oil, supplied to the pressure pump from the aircraft-fur-

nished tank, is delivered through a disc-type filter, also on the accessory housing front face, to the cored passages and tubes within the engine. A pressure-regulating valve, located in the main oil pump, senses pressure at the filter outlet and limits the oil pressure delivered by the pump to a predetermined value. A safety bypass valve, designed to bypass oil around the filter in the event the filter becomes clogged, is incorporated between the cored passages leading into and out of the filter. A check valve designed to open at 8-psi differential pressure is included in the system in order to prevent oil from seeping into the power section after shutdown.

Oil for lubrication of the compressor rotor bearings and the turbine rotor bearings flows from the compressor extension shaft through the center of the compressor and turbine-to-compressor drilled tie-bolts. Drilled passages in the last-stage compressor wheel hub, and turbine shaft, permit oil distribution to the rotor bearings. Surplus oil to the compressor rear bearing drains to a sump in the compressor diffuser where the diffuser scavenge pump assembly picks it up and returns the oil through tubes in the compressor diffuser and housing to the outlet side of the main scavenge pump. Surplus oil from the turbine front bearing is picked up by the turbine front scavenge oil pump and directed through a tube in the turbine front bearing front sump to the diffuser scavenge pump tube assembly. Oil which lubricates the turbine rear bearing falls into the sump of the rear turbine scavenge oil pump assembly; it is directed by the turbine scavenge oil pump through a tube inside the turbine-to-compressor tie-bolt and through an annulus formed by this tie-bolt and the turbine coupling shaft assembly to the front of the turbine shaft. From here it drains through splines in the turbine coupling shaft to either the turbine front bearing sump or the diffuser sump. Here it is picked up by the compressor diffuser and turbine front scavenge oil pumps and returned to the main scavenge oil pump outlet.

A scavenge pressure relief valve is incorporated in the system as a safety measure in the event the scavenge outlet becomes restricted.

Anti-Icing Protection

Anti-icing protection is provided for the extension shaft housing shroud, the inlet housing struts, the compressor inlet guide vanes, and the compressor inlet temperature and pressure probes.

The primary control for the anti-icing system is a solenoid-actuated valve mounted on the compressor assembly. An anti-icing valve is mounted on either side of the air inlet housing. When the system is in operation, compressor discharge air, taken from the diffuser assembly, passes through an external line to the anti-icing valves and thence through internal passages in the inlet housing to the points mentioned above.

Air Bleed

Air bleed, furnished at compressor discharge conditions, is provided from ports on the engine diffuser. A maximum of 8% of the engine inlet air is available by manifolding more than one port. Large adverse changes in engine power and specific fuel consumption are experienced when using this bleed air; typically, for 1% engine air, a power loss of 3% and a specific fuel consumption increase of 2% are suffered.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

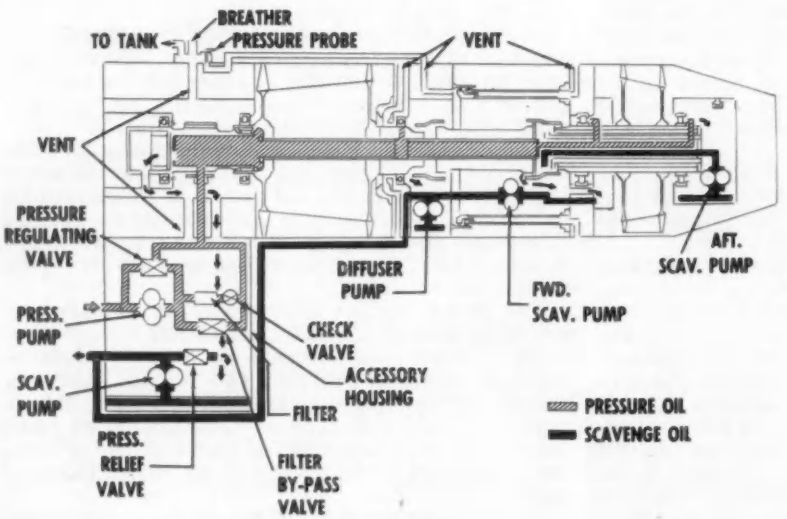


Fig. 6—Power section oil system of T56-A-1 engine.

This concludes a two-part article on the use of fuel injection in gasoline automobile engines. Part I appeared in the January SAE JOURNAL, pp. 61-66.

Fuel Injection For Gasoline Automobiles Part II

GASOLINE fuel injection systems currently in use and those still in the development stage differ from each other both in basic principles and in the design of specific components. In one system fuel is injected directly into the combustion chambers; in another fuel is sprayed into the manifold behind the intake valves. Fuel may be timed and metered in individual charges, or supplied in a continuous flow, or regulated by the use of an injection carburetor. There may be one common fuel line or a separate fuel line for each cylinder. Fuel-air mixture may be controlled by manifold pressure, engine speed, the airflow velocity, or a combination of the three. At the point of injection there may be a high-pressure spray nozzle or a low-pressure orifice.

No matter how the systems differ, however, they all have common goals: to deliver the fuel to the engine cylinder in just the right amounts and at precisely the right time. Of course it is desirable that manufacturing costs of the system are competitive with carburetor systems, and that engine performance and fuel economy are improved significantly to warrant replacing carburetion by fuel injection. Various gasoline injection system manufacturers and automobile companies have their own unique designs which—they claim—approach the above goals. The systems will be described in the following pages.

American Bosch Arma Corp.—

Fuel is injected at the intake port through a spring-loaded nozzle at about 75-psi fuel pressure. A schematic of the system is shown in Fig. 1.

The **injection pump**, shown in Fig. 2, consists of an integral 8-lobe-face cam and plunger (A), recipro-

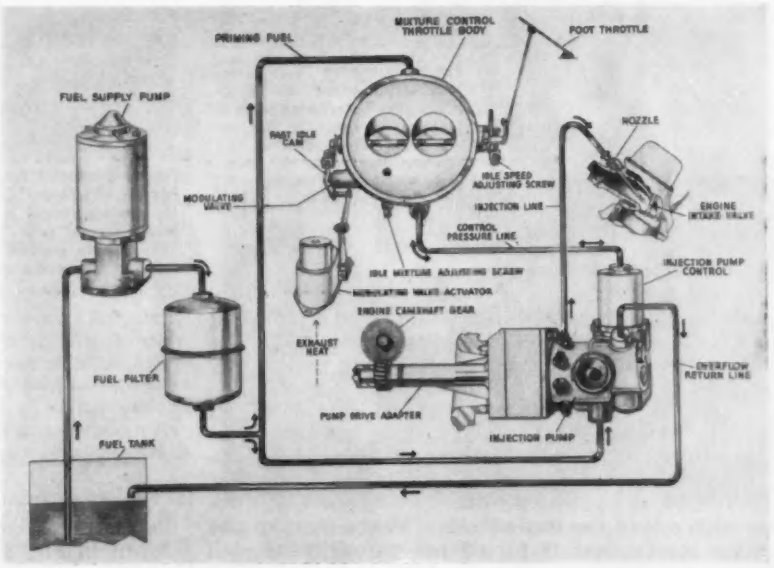


Fig. 1—Schematic of American Bosch gasoline fuel injection system.

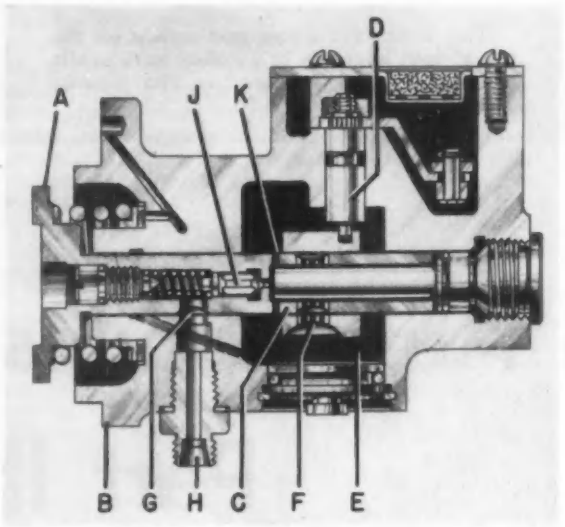


Fig. 2—American Bosch fuel injection pump consists of (A) Integral 8-lobe-face cam and plunger, (B) Housing, (C) Metering sleeve, (D) Eccentric shaft, (E) Sump, (F) Radial ports, (G) Distributing port, (H) Outlet, (J) Delivery valve, (K) Spill ports.

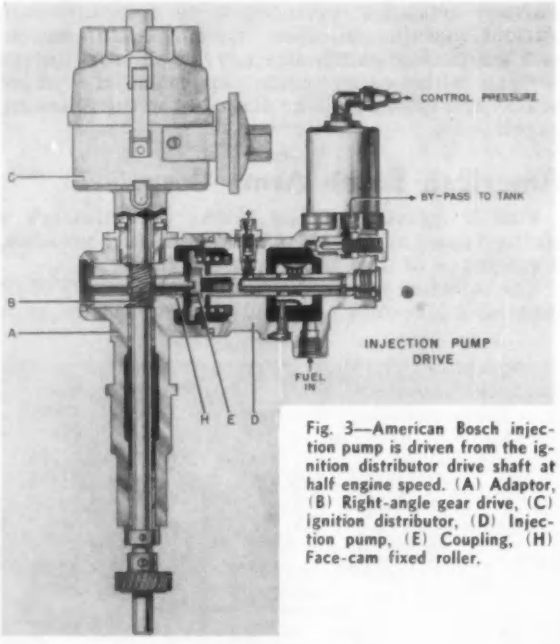


Fig. 3—American Bosch injection pump is driven from the ignition distributor drive shaft at half engine speed. (A) Adaptor, (B) Right-angle gear drive, (C) Ignition distributor, (D) Injection pump, (E) Coupling, (H) Face-cam fixed roller.

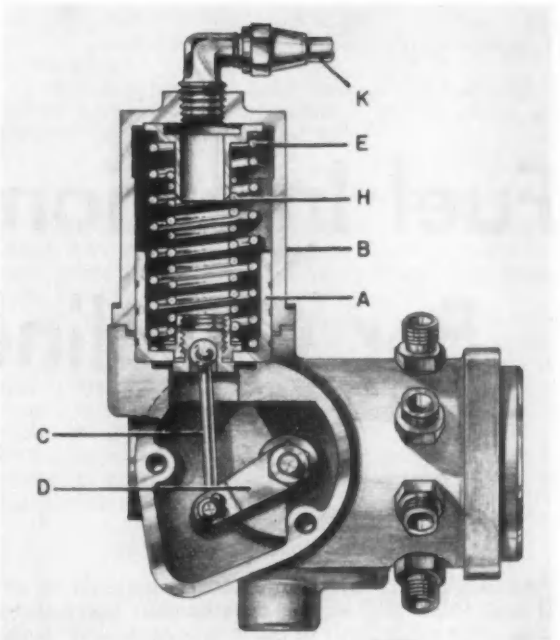


Fig. 4—American Bosch injection pump control consists of (A) Piston, (B) Cylinder, (C) Link, (D) Metering control lever, (E) Outer spring, (H) Free inner spring, (K) Control pressure tube.

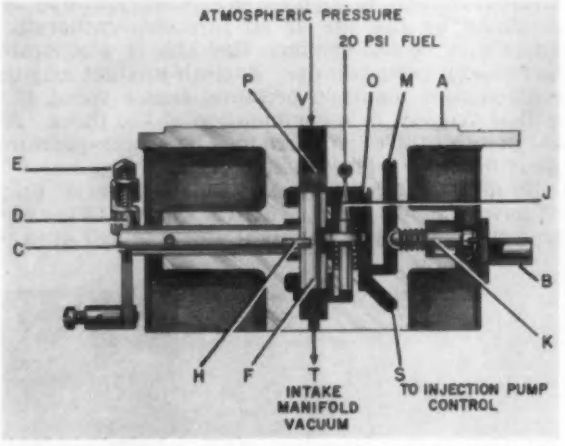


Fig. 5—Section of American Bosch Mixture Control. (A) Throttle body casting, (B) Shaft, (C) Eccentric shaft, (D) Fast-idle cam, (E) Throttle idle adjustment screw, (F) Warm-up valve, (H) Pin, (J) Spring-loaded priming valve, (K) Screw, (M) Idle slot, (O) Control chamber, (P) Running position of valve F, (S) Connection to injection pump control, (T) Intake manifold vacuum.

cating and rotating within housing (B). A metering sleeve (C) is fitted to the plunger to control the fuel spill point. It is adjusted for metering position by eccentric shaft (D).

During the suction stroke, fuel from the sump (E) fills the internal volume of the plunger through radial ports (F) in the plunger and sleeve. As the plunger turns, the fill ports are covered at the end of the suction stroke and the distributing port (G) lines up with one of the outlets (H). At the start of the pump stroke, fuel is forced out through the spill ports (K) to sump (E) for that part of the stroke determined by the metering sleeve position. As the plunger lifts further, the spill ports are covered by the sleeve and fuel is then forced through the delivery valve (J) and out through distributing slot (G) to a nozzle line. Injection continues to the end of the stroke and the cycle repeats for an adjacent outlet.

The injection pump is driven from the ignition distributor drive shaft at half engine speed. As shown in Fig. 3, an adaptor (A), housing a right-

angle gear drive (B) is interposed between the camshaft drive and the ignition distributor. The ignition distributor (C) mounts on the top of the adaptor and the injection pump (D) is on the side. The injection pump is driven by the cross-shaft through coupling (E). The face-cam fixed roller (H) is also carried by the adaptor.

The **injection pump control** (Fig. 4) is mounted directly on the injection pump. It receives control pressure for the mixture control through tube (K) and translates it into an angular movement at the metering shaft of the injection pump. The control consists of a piston (A) operating in cylinder (B) and biased against control pressure by springs (E) and (H). Piston (A) is connected to metering control lever (D) by link (C). At high control pressure corresponding to low manifold vacuum (wide-open throttle) piston (A) is moved down toward maximum fuel position (shown) by outer spring (E). As engine speed increases, the control pressure is reduced and piston (A) is forced upward against spring (E) at a constant rate until free inner spring (H) reaches its seat, at which time spring (H) adds its effect to spring (E) and the rate of piston travel with change in control pressure is reduced.

Since piston (A) is mechanically linked to pump metering control lever (D), the fuel quantity injected per pump stroke is a function of control pressure applied to the piston.

The mixture control in its basic and simplest form is merely a manifold pressure control and throttle-body with a chamber feeding a modified manifold pressure to the injection pump control during cold starting and idling.

A section of the mixture control is shown in Fig. 5. In this view the throttle plates mounted on shaft (B) are not shown but are of conventional design with an idling port just above the closed throttle position and connected to passage (M). The valve positions shown correspond to a cold engine condition. Since a cold engine requires excess fuel during the warmup period and since the injection pump meters to a control pressure curve, the control pressure must be raised during warmup to increase the pump delivery. This enrichment is accomplished as follows:

A control chamber (O) is formed in the throttle-body casting and is connected at (S) with the injection pump control. A vertically slidable valve (F) operates within a passage between upper- and lower-deck pressures. When the valve (F) is in its lower position as shown, the pressure in chamber (O) is between that of (V) and (T). When the valve (F) is in its upper or normal running position (P), the chamber pressure is that of (T) or manifold pressure. The injection pump therefore delivers additional warmup fuel to the engine until valve (F) reaches position (P).

Valve (F) is operatively connected through pin (H) and eccentric shaft (C) to a lever which also carries a fast-idle cam (D) cooperating with a throttle idle adjustment screw (E). The lever itself may be actuated by a manual choke wire or an automatic operator responsive to exhaust or water temperature.

To assure good cold-starting of the engine, a fuel flow considerably greater than the full-load quantity is required. This could be provided by using a larger injection pump. The size and cost, however, of such a double or triple-sized pump makes it necessary to use other means of cold-priming. Since supply fuel at a pressure of 20–30 psi is available as soon as the ignition key is turned on, a convenient source of pressurized fuel is at hand and may be used for priming. A spring-loaded priming valve (J) mounted adjacent to warmup valve (F) is held normally closed on its seat against fuel supply pressure by a spring. An extension on valve (J) engages in a slot in valve (F) so that in the cold position a slight additional movement of shaft (C) allows valve (F) to en-

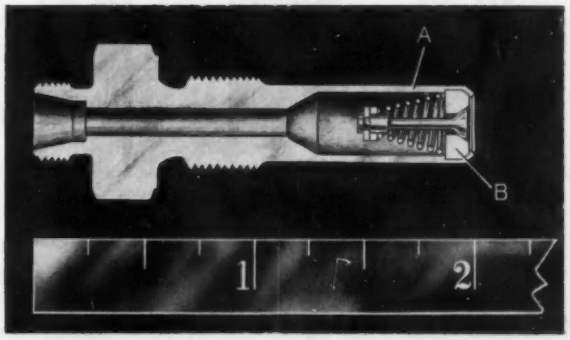


Fig. 6—American Bosch Spray nozzle is outwardly opening poppet type. (A) Holder, (B) Valve assembly.

The Authors

This article is based on papers presented at SAE national and section meetings during the past few months. They are available in full in multilith form from SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Automotive Gasoline Injection

S. E. Miller, American Bosch Division
American Bosch Arma Corp.

Simmonds Fuel Injection System for Gasoline Engines

Alex Hossack, Simmonds Aerocessories, Inc.

A special publication compilation of papers (SP 140) presented at the Detroit Section Symposium on Fuel Injection, White Sulphur Springs, Sept. 9, 1955 is also available. Price: $1.50 to members, $3.00 to nonmembers. Authors of these papers are:

E. J. Gay, Technical Consultant

E. K. Von Mertens,
American Bosch Arma Corp.

C. A. Lindblom, International Harvester Co.

A. L. Pomeroy, Thompson Products, Inc.

J. E. Taylor, Gulf Research and Development Co.

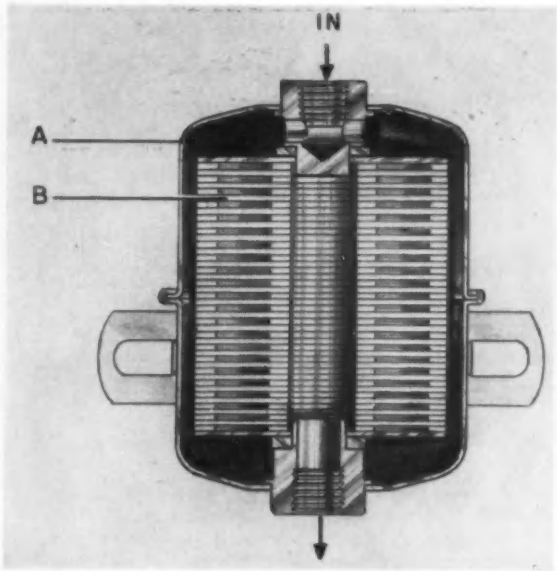


Fig. 7—American Bosch fuel filter. (A) Steel enclosure, (B) Alternate layers of high wet-strength paper and fiber spacers.

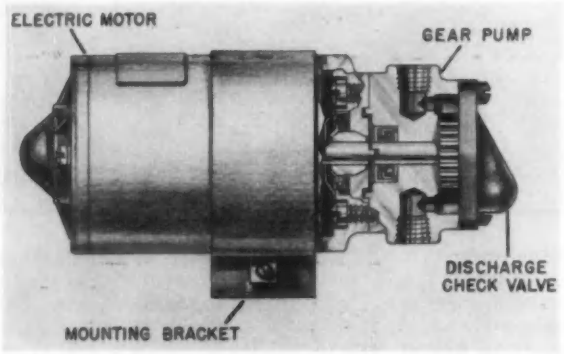


Fig. 8—American Bosch fuel supply pump is electric driven.

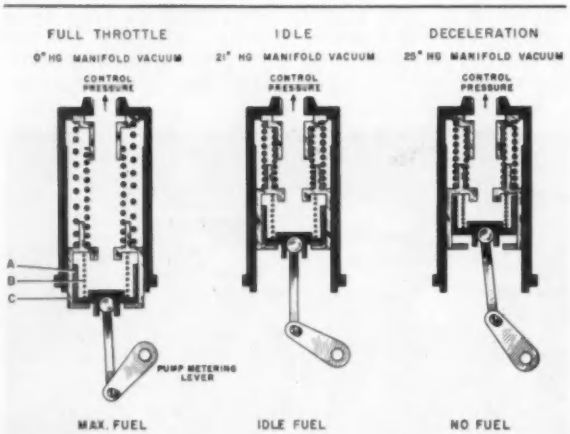


Fig. 9—Fuel cut-off device. (A) Piston, (B) Low-rate spring, (C) Pump control piston.

gage priming valve (J) and open it. Fuel then is discharged into the control chamber and enters the intake manifold through passage (T). The additional movement of shaft (C) necessary to actuate the primer valve (J) may be furnished conveniently by a small solenoid acting through the heat-responsive element and energized by the electric starter circuit. By having the primer solenoid act through the heat-responsive element, priming is prevented on any hot restart.

The idle airflow is adjusted in the usual manner by screw (E). The idle mixture is adjusted by screw (K) which at idle receives inlet air pressure through idle slot (M) and modifies the control chamber pressure. Above the idle setting the throttle plate edge rises above the idle port, the idle port becomes manifold pressure, and the screw (K) has no effect on engine mixture.

The **spray nozzle** of the American Bosch system is an outwardly opening poppet type, as shown in Fig. 6. It consists of a valve assembly (B) rolled into a holder (A), which is available in several lengths to satisfy various engine and manifold requirements. Opening pressure is 70 psi and atomization is very good at all quantities due to the floating and self-aligning pintle action.

The **fuel filter** (Fig. 7) is especially designed for gasoline. The filter element (B) is built up of alternate layers of high wet-strength paper and fiber spacers inside a steel enclosure (A), and provides 2-micron filtering of the fuel. Service life is approximately 30,000 miles.

Fuel supply pump (Fig. 8) consists of an electric motor-driven gear-type pump with a discharge check-valve that retards the decay of pressure in the system during temporary engine shutdown. A pressure regulating valve built into the injection pump holds system pressure at 20 psi.

Full or partial cut-off of fuel-flow during deceleration can be accomplished automatically by a device shown in Fig. 9. It consists of an auxiliary piston (A) biased by a low-rate spring (B) which balances the piston force at 22 in. of Hg manifold vacuum. Piston (A) is mechanically linked to the pump metering lever and is carried within pump control piston (C). During normal operation from idle to full throttle, piston (A) moves with piston (C) as a unit. When engine deceleration occurs and manifold vacuum exceeds 22 in. of Hg, piston (A) moves upward within piston (C) and the fuel pump metering lever is moved into the fuel cut-off position.

Robert Bosch G.m.b.H. of Stuttgart, Germany

Fuel is injected directly into the combustion chambers at the comparatively high pressure of 640 psi. Fig. 10 shows the Robert Bosch system installed on a 6-cyl gasoline engine.

The multiple unit injection pump consists of individual pump elements, one for each cylinder. Each element consists of a plunger of constant stroke and a very close-fitting barrel. The plunger has a feed hole which connects a suction chamber in the pump housing with the pressure chamber in the pump barrel. Fuel is delivered to the suction chamber from the fuel tank by an engine-driven fuel supply pump at a fuel line pressure of 1700 psi.

The plungers are driven by an eccentric shaft

which in turn is controlled by a diaphragm which senses manifold conditions across the throttle butterfly valve and the venturi in the air intake manifold.

A helical groove is cut into the top of the plunger jacket and acts as a control edge. As the plunger is turned in the barrel the amount of delivered fuel is adjusted.

On the suction stroke fuel is drawn by the pump plunger from the suction chamber through the feed hole to the pump barrel. During the compression stroke it is forced into the pressure pipe connected to the cylinder. As the plunger uncovers the feed hole again and the compression chamber is connected to the suction chamber through the longitudinal groove, the fuel delivery stops. Plunger is returned by a spring.

Excess fuel is spilled back to the fuel tank by a fuel return line.

A sensing device provides necessary correction to the control diaphragm for changes in ambient pressures and temperatures.

The Robert Bosch system is currently being used on the Daimler-Benz 300 SL, the Daimler-Benz 300 SC, and the Daimler-Benz 2.5-liter racing car. (The latter was recently victorious in all the 1955 European races.) More than 20,000 Robert Bosch fuel injection systems are being used on the Goliath 700, Goliath Express, and Goliath 900 automobiles, on the BMW 2-cyl racing motorcycle, and the Borgward 1.5-liter sports car.

Simmonds Aerocessories, Inc.—

The Simmonds Aerocessories SU system was designed for light and medium horsepower aircraft, and has been modified for trucks, passenger cars, and military tracked vehicles. It is a multiple point, low-pressure, timed, speed-density injection system.

Simmonds claims that the low-pressure system, injecting into the manifold, can be made at lower cost than the high-pressure system, which injects into the combustion chamber.

Also, timed injection systems provide a much better ability to achieve low and intermediate speed fuel economy and a much better idle potential than a continuous-flow system.

The fuel injection pump can be installed on single-cylinder or multicylinder engines. Prototypes have been used on engines from 250 cu in. to 1300 cu in. and on engines of 100 to 600 hp.

Simmonds is presently adapting it to a 1500-hp engine.

The injection pump consists of three main elements (shown in Fig. 11): the control system, the metering system, and the distributing system.

The control system is a servo system which uses a combination of manifold pressure and temperature for an input signal and oil pressure for power. This is achieved by exposing a nitrogen-filled capsule to manifold pressure. The nitrogen is confined to the capsule and connected to a bulb by means of a capillary tube.

The bulb is placed in the air induction system and senses air induction temperature. The capsule then assumes a position in response to the pressure differential created by the sensing of the temperature and pressure of the air in the intake manifold. The capsule is connected to a valve member which responds to the capsule setting by creating an orifice between the valve and the mainshaft which, in turn, allows oil to flow from the oil supply side of the z-shaft to the servo side of the z-shaft. The servo side is drained by a fixed orifice path. The resulting

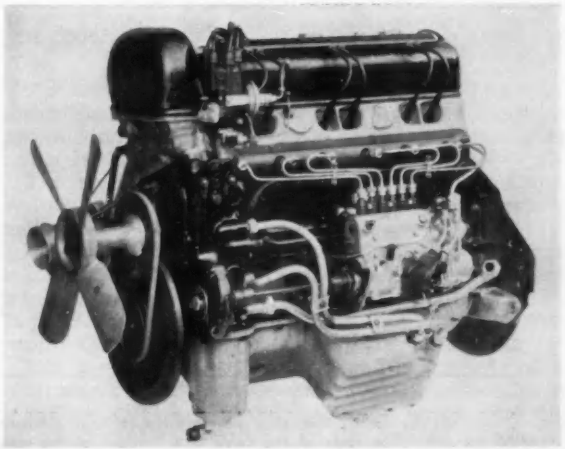


Fig. 10—Robert Bosch of Stuttgart, Germany, fuel injection system is shown installed on a 6-cyl gasoline engine.

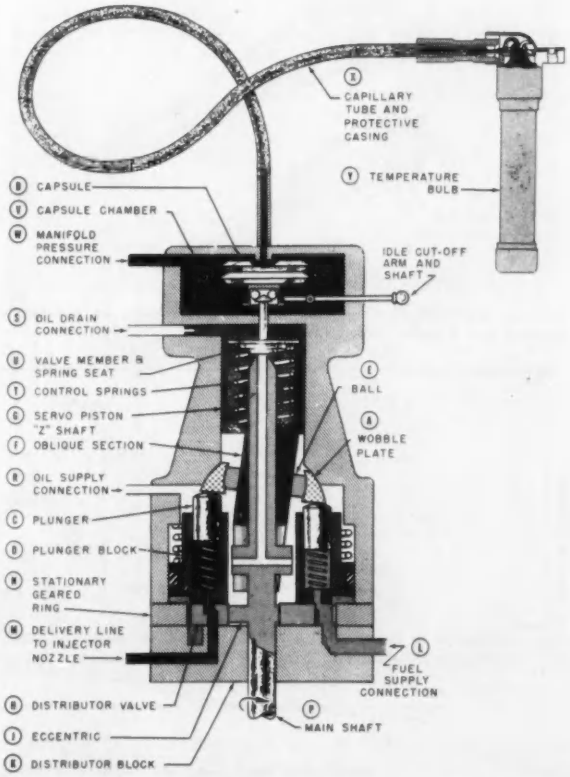


Fig. 11—Simmonds Aerocessories fuel injection metering, control, and distributing device.

pressure differential occurring across the piston moves the z-shaft to a calibrated position.

The metering system consists of a multicylinder wobble plate pump. The wobble plate oscillates in a spherical seat and is wedded to the z-shaft by a wedding ring. The wobble plate assumes an angle with respect to the mainshaft in direct proportion to the displacement of the center of the z-shaft from the center of the mainshaft. This angle directly changes the magnitude of the stroke, and consequently, the flow of fuel.

The distributing system consists of a stationary ring gear, inside of which there is a rotating distributing valve geared to the ring gear in the ratio of 8/9 and actuated by a cam on the mainshaft. The resulting epicycloid path is used to provide juxtaposition of the proper plunger, a port in the valve, and an outlet on the distributor block. This alignment is designed to take place at a point where the rotational velocity of the distributor valve is at a minimum. The injection takes place during 180 deg crankshaft, and occurs during the induction cycle. Tests have shown that the relation of the injection period to intake valve opening is not critical.

The pump itself is driven at engine speed. Therefore, half as many plungers as engine cylinders are required. One plunger injecting into one cylinder on one revolution and into another cylinder 360 crank deg later on an alternate revolution.

The flow from the individual outlet port is conveyed through piping to a nozzle (see Fig. 12) in the intake manifold near the intake valve. The nozzle consists of a filtering element and a spring-loaded valve. The valve is calibrated to open when the pressure rises to between 85 and 110 psi, depending on installation requirements. The line length is immaterial. Since the nozzles are not part of the metering system, they need not be matched. Their prime function is to contribute toward a satisfactory spray pattern during injection and to maintain a full fuel line between injection periods and during shutdown.

The pump will respond to a change in engine condition in the following manner.

1. When the throttle is opened the manifold pressure will increase, causing the capsule to compress. The movement of the capsule creates a greater orifice at the end of the mainshaft, and increases the flow from the oil supply side of the servo piston to the servo side. Since oil drains from the servo side of the servo piston through a fixed orifice, the pressure differential across the piston decreases and the metering springs force the z-shaft downward creating a new balance of forces. This increases the wobble plate angle and increases the fuel flow.
2. When the throttle is closed the manifold pressure decreases. The capsule expands, reducing the oil flow through the mainshaft, increasing the pressure differential, and forcing the z-shaft upward. This reduces the fuel flow.
3. For an increase or decrease in air intake temperature, the nitrogen in the capsule expands or contracts, varying the fuel flow.
4. A change in ambient pressure conditions causes a response similar to opening or closing the throttle. Any variation of load with a constant throttle opening is sensed by variations in manifold pressure.

The pump is matched to an engine by obtaining fuel flow requirements of the engine for the com-

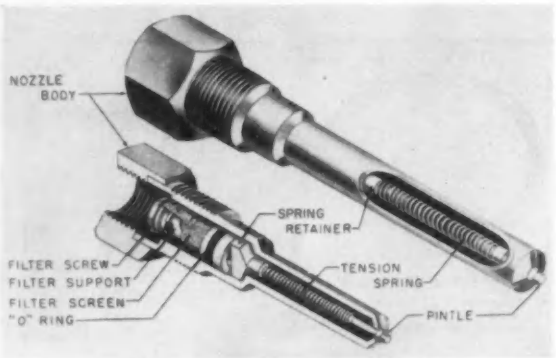


Fig. 12—Simmonds fuel injection spray nozzle consists of a filtering element and a spring-loaded valve.

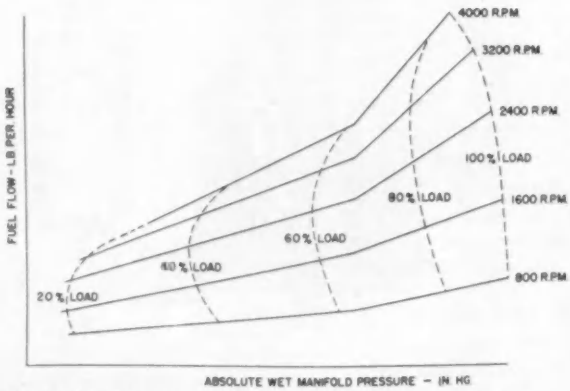


Fig. 13—Fuel flow requirements of the engine over a complete range of load and speed settings.

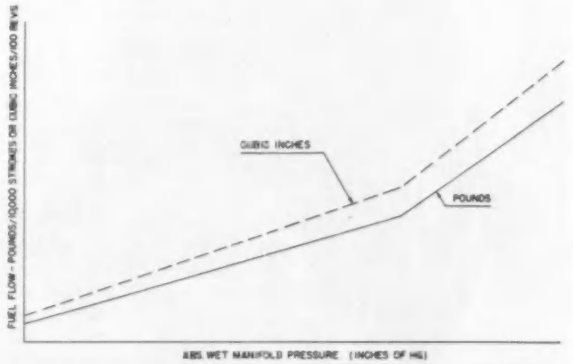


Fig. 14—Calibration curve: fuel flow per injection against absolute manifold pressure. The slope of the curve is a function of the rate of the springs.

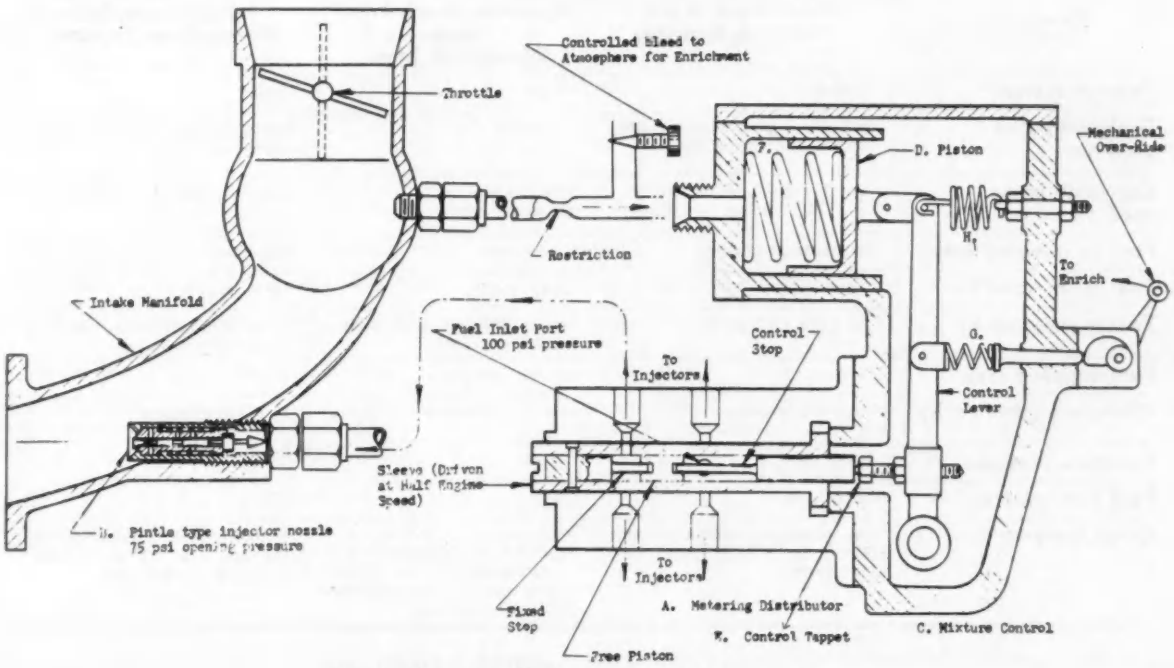


Fig. 15—Schematic of the Joseph Lucas fuel injection system.

plete range of load and speed settings. (See Fig. 13.) This information is translated into terms of fuel flow per cylinder per revolution or, fuel flow per injection. These data enable a calibration curve to be plotted: fuel flow per injection versus absolute manifold pressure. (See Fig. 14.)

The knee of the curve is created and positioned by using two springs of different lengths and rates. The slope of the curve is a function of rate of the springs. The intersection, or knee, is a function of the length of the shorter spring.

Joseph Lucas, Ltd., of Birmingham, England

The Lucas system was designed to be used on passenger cars, trucks, buses, and high-performance sports cars, and has been used on experimental cars in England.

Timed fuel charges are injected into the manifold or into the intake port. Fuel mixture is controlled by manifold pressure.

A schematic of the Joseph Lucas fuel injection system is shown in Fig. 15. Fuel is delivered to the intake port by a spring-loaded, pintle-type nozzle at 75 psi. An electric-driven pump, located in the fuel supply tank feeds fuel to the injector at 100 psi.

The metering distributor (Fig. 16) consists of a rotating sleeve driven at camshaft speed. The sleeve is hollow and has one port along its length and diameter for each cylinder. In the hollow portion of the sleeve is a shuttle, or free piston, that is forced back and forth by fuel under pressure, thus uncovering inlet and outlet ports. The travel of this piston is limited by a control stop. The control stop is linked to a piston whose position is a factor of spring loading and manifold depression. Corrections for air pressure and air temperature can be

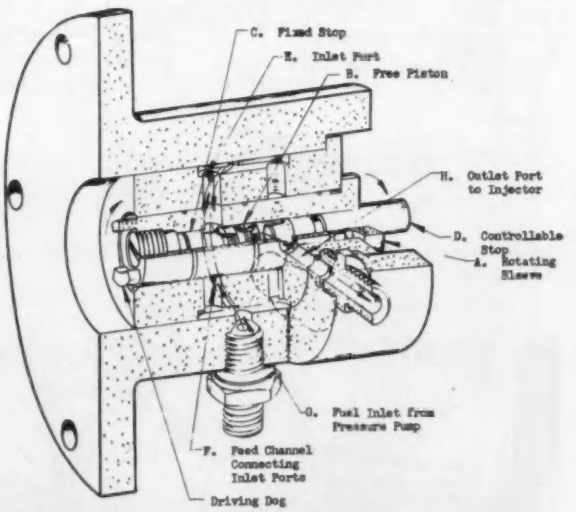


Fig. 16—Joseph Lucas metering distributor consists of a rotating sleeve driven at camshaft speed. A shuttle in the hollow sleeve uncovers fuel inlet and outlet ports as it is forced back and forth by fuel.

Company	Robert Bosch G.m.b.H. Stuttgart, Germany	American Bosch Div. American Bosch Arma Corp. Springfield, Mass.	Joseph Lucas, Ltd. Birmingham, England
Type of system	timed	timed	timed
Designed to be used on	passenger cars, trucks, buses, sports and racing cars	passenger cars	passenger cars, trucks, buses, sports cars
Currently being used on	Daimler-Benz 300SL, 300SC, 2.5 liter racing car, Goliath	test projects on passenger cars	experimental cars in England
Fuel is injected into	combustion chamber	intake port	manifold or intake port
Fuel is injected by	spray nozzle	spray nozzle	spray nozzle
Fuel is metered by	multiple unit pump	single plunger pump with metering sleeve	positive displacement within a distributor valve
Fuel supply pump	engine driven	electric driven	electric driven
Mixture controlled by	manifold pressure	manifold pressure	manifold pressure
Injection pressure	640 psi	75 psi	75 psi
Fuel line pressure	1700 psi	20 psi	100 psi
Other features	In principle, similar to the Robt. Bosch high speed diesel system.	Auto choke Fuel cut-off during deceleration Excess fuel for cold starting Spill type metering	Metering and distribution of the fuel is at 100 psi, which eliminates vapor lock.

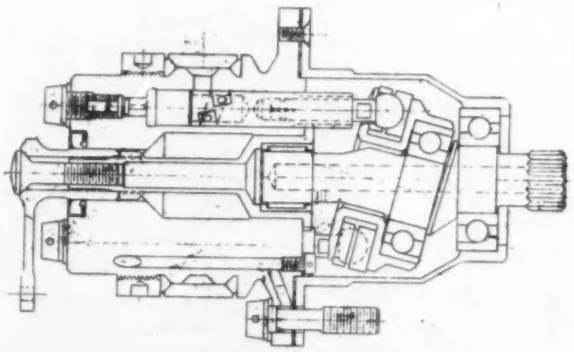


Fig. 17—Fuelcharger Corp. multiplunger injection pump has one plunger for each cylinder.

applied. A mechanical over-ride is provided for cold starting and warmup.

Fuelcharger Corp.—

Fuelcharger Corp. in Detroit has three gasoline injection systems designed to meet various engine requirements and price brackets.

The M-3 timed injection system uses a multiplunger pump. (See Fig. 17.) There is one plunger for each cylinder that is mechanically returned, thereby eliminating springs. A poppet valve nozzle, shown in Fig. 18, is usually located for injection directly into the combustion chamber. Fuel mixture is controlled according to engine speed-air density or by mass airflow. This system is comparatively expensive when all components are counted in the overall price.

The S-2 timed injection system uses a single plunger pump. The plunger rotates and reciprocates

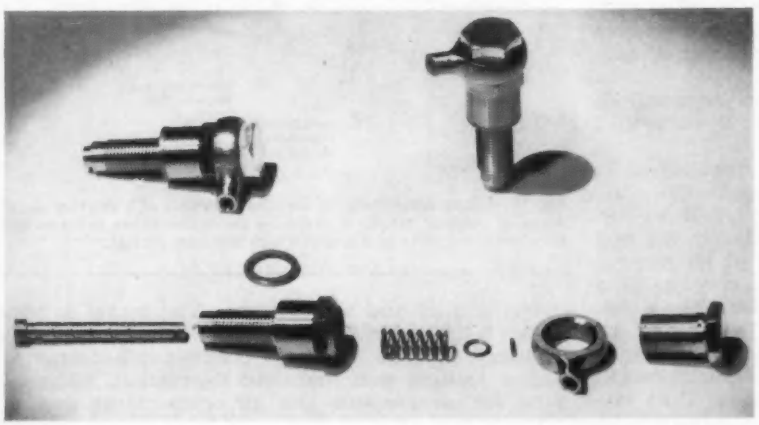


Fig. 18—Fuelcharger Corp. poppet valve nozzle.

Simmonds Aerocessories, Inc. Tarrytown, New York	Fuelcharger Corp., Detroit, Michigan		
	M-3 System	S-2 System	#491110 System
timed	timed	timed	continuous flow
passenger cars, trucks, buses, light and medium horsepower aircraft	passenger cars, trucks, buses	passenger cars, trucks, buses	passenger cars, trucks, buses
military tracked vehicles			
intake port	combustion chamber	manifold	intake port
spray nozzle	poppet valve nozzle	closed or open nozzle	open orifice (0.012 in.)
multiple unit injection pump	multiple plunger injection pump	single plunger pump	one electric pump provides pressure for fuel supply and fuel injection
engine driven	electric driven	electric driven	
manifold pressure, engine speed, manifold temperature	manifold pressure, engine speed	manifold pressure, engine speed, or mass-airflow	manifold pressure, engine speed, or mass-airflow
115 psi	100-1000 psi	100-200 psi	5-160 psi
20 psi	10-30 psi	10-30 psi	5-160 psi
System recently passed 150 hr airforce-type test.	Pump plungers have variable beginning-constant ending strokes and are returned mechanically.	Cost is approximately ½ M-3 system.	Cost is approximately 1/10 M-3 system.

as it pumps and distributes fuel to the various cylinders. The spray nozzle is located in the intake manifold. Closed or open nozzles may be used. Fuel mixture is controlled by engine speed-air density, or by mass airflow. This system, complete with components, will cost about half the M-3 system.

Fuelcharger also has a continuous flow injection system. Since there are no precision ground and lapped parts it costs only 10% the cost of the M-3 timed injection system. Only one pump is used which both transfers and injects the fuel. It is a small electric-driven pump located in the fuel tank. Current for the pump motor is supplied by a small variable output generator which is engine-driven. A small rheostat operated by inlet manifold pressure controls the generator output to the pump motor. Thus fuel pressure and flow is sensitive to engine speed, engine load, and manifold pressure.

Fuel is supplied from the pump through a common "rail" to open orifice nozzles in each cylinder inlet port. Pump pressures vary from 5 psi at idle to 160 psi at full throttle. When the starter is switched on, current from the vehicle battery drives the fuel pump, which quickly purges the fuel line of air and vapor and delivers fuel to each nozzle in the intake ports.

Fuelcharger says performance tests on recent V-8 engines using this system indicate that fuel economy at maximum power, part load, and idle is equal to that of the more expensive plunger-timed systems and better than the economy which can be achieved with 4-barrel carburetor systems. Fig. 19 shows an installation of a Fuelcharger system on the Lincoln V-8 engine.

Other experimental systems—

In addition to the gasoline fuel injection systems described above, there are several more being developed by automobile companies and parts manufacturers.

Bendix Aviation Corp. has three different divisions working on types of fuel injection suitable for automobiles, each along a somewhat different line. Bendix is primarily concerned with devising a fuel injection system that can equal or better carburetor performance *under all the varied conditions of service.*

General Motors, Thompson Products, and Ford are also experimenting with fuel injection systems.

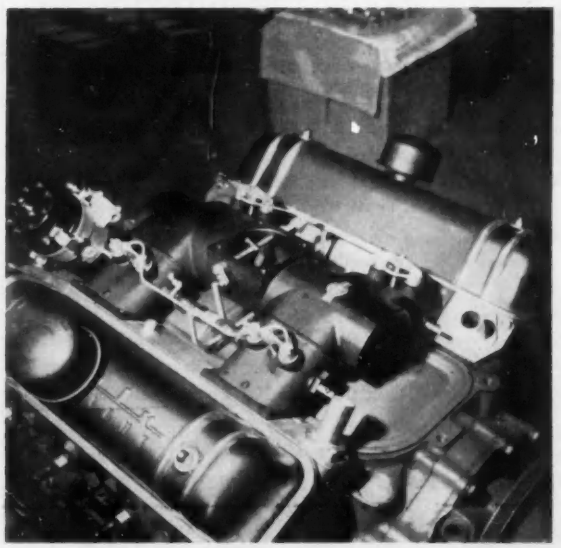
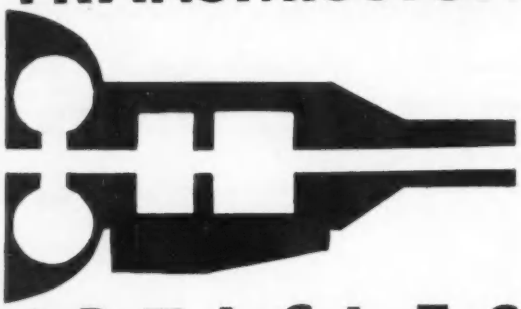


Fig. 19—Fuelcharger Corp. fuel injection system installed on a Lincoln V-8 engine.

This is the first of seven

AUTOMATIC TRANSMISSION



ARTICLES

in this issue of SAE Journal.

JUST in case you've lost sight of the basic elements of automatic transmissions as the trade-named combinations of the elements have become more numerous and more complex, we offer, beginning on these pages, a review of the fundamentals.

Transmissions, even the fanciest of them, have just one purpose to accomplish: to adapt the gasoline engine, which develops power in proportion to its speed, to the vehicle, which usually requires highest power at lowest road speed.

Reason for going from manual to automatic transmissions is to make driving easier, smoother, and quieter.

Just how the basic elements have been arranged to achieve these goals in six current automatic transmissions is explained in six articles following this first one. The articles are:

American Automatic Transmissions page 36
S. E. Swallow, Ford Motor Co. of Canada, Ltd.

What's New about the 1956 Hydra-Matic page 42
Kenneth W. Gage and **P. J. Rhoads**, Detroit Transmission Div., GMC

What's New about the 1956 Dynaflow page 50
R. J. Gorsky, Buick Motor Div., GMC

The Twin Ultramatic Transmission page 57
C. J. Lucia and **J. Z. DeLorean**, Studebaker-Packard Corp.

Lincoln's Turbo Drive Transmission page 60
H. G. English, Ford Motor Co.

The Powermatic page 63
H. O. Flynn, Chevrolet Motor Div., GMC

The Allison TC-12 Torqmatic Transmission page 67
R. C. Williams, **H. C. Kirtland**, and **C. M. Jordan**, GMC
Euclid Div. Allison Div. Styling Section

Three Elements Are

American

1. Fluid coupling or
2. Planetary gearing
3. Band, clutches, and

1. Fluid Coupling or Torque Converter

The fluid coupling is capable of transmitting torque efficiently but is not able to increase or multiply it.

The torque converter, on the other hand, though similar in appearance, is capable of increasing or multiplying torque. In this respect it is ideal for a passenger car transmission except that in general the higher its torque multiplication the lower is its efficiency. It is therefore necessary to restrict its torque multiplication effect in practice in order to maintain its efficiency at a permissible level.

A fluid coupling operates not unlike an electric fan and a child's pinwheel. The fan is driven by an outside means and pushes fluid—air in this case—towards a pinwheel. Some of the energy in the moving air is absorbed by the pinwheel making it rotate.

The fluid coupling (Fig. 1) operates on the same principle. The driving torus at the left is directly connected to the engine. As it turns it sends oil whirling into the driven member which, like the pinwheel, turns. Note that the oil not only spins with the driving torus but has a helical motion as well—as shown by the arrows.

When the driving member of the coupling falls below a certain speed there is not sufficient energy in the oil to move the driven member and we have, in effect, a disengaged clutch.

In a simple torque converter (Fig. 2) the driving member or pump sends oil into the driven member or turbine. Striking the turbine blades the oil delivers up its energy, changes its direction, and is expelled from the vanes.

At this point in the circuit another bladed mem-

S. E. Swallow, Service Manager, Ford Motor Co. of Canada, Ltd.

Excerpts from paper "Automatic Transmission for Passenger Cars" presented at SAE Montreal Section, Oct. 17, 1955.

Common to All

Automatic Transmissions

torque converter—to give smooth, quiet operation

—to produce a variety of effective transmission ratios

other control means—to control the gearing automatically

ber called the stator is inserted into the system. In it the direction of flow is again changed, and the velocity is artificially increased so that in returning to the pump the oil adds additional driving momentum to it. This is in addition to the torque already being delivered to the pump from the engine, and we have torque multiplication.

In practice, the pump is attached to the case and driven from the engine.

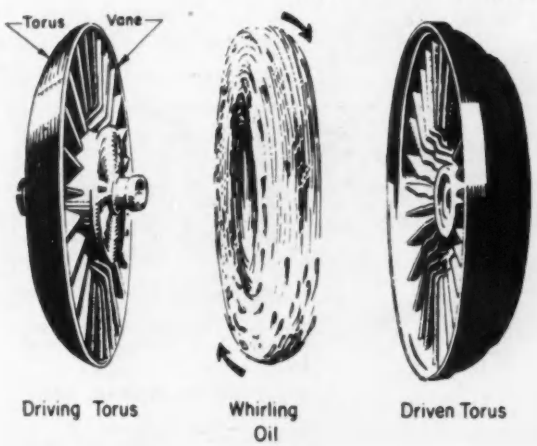
When the car is at a standstill the turbine is stationary. As the accelerator is pressed down the pump speeds up and fluid at high speed enters the turbine, imparting energy to it. The fluid then passes to the stator, is redirected, and comes back into the pump.

Soon, enough energy is imparted to the turbine to overcome the vehicle's starting friction and the turbine begins to rotate. As it does, it too wants to throw fluid to the outside. This opposes the pump flow. The rate of flow is thus reduced. So, therefore, is the torque multiplication.

When the turbine speed approaches the pump speed, the flow virtually ceases and the multiplication of torque is down close to 1/1. If as in coasting, the turbine speed overruns the pump speed, then the one-way clutch lets the stator overrun and there is no torque converter action.

As the turbine speeds up from 0 to 9/10 of pump speed the torque increase characteristically falls from about 2/1 to 1/1. This 1/1 ratio speed is called the coupling point. From that speed on the torque converter acts generally like a regular fluid coupling.

Fig. 1—Fluid coupling



2. The Planetary Gearing

The planetary gear set offers several power transmitting arrangements. It can furnish several reduction ratios plus reverse. Therein lies its usefulness.

At the center of Fig. 3 is the sun gear. In mesh with it are three planet gears. These are on pinions, and the pinions are held in position by a planet carrier. Surrounding the planet gears and again in mesh is the internal tooth gear.

Power can be applied, or taken out, at the sun gear, the planet carrier, or the internal tooth gear.

If we hold the internal tooth gear stationary and

Fig. 2—Torque converter

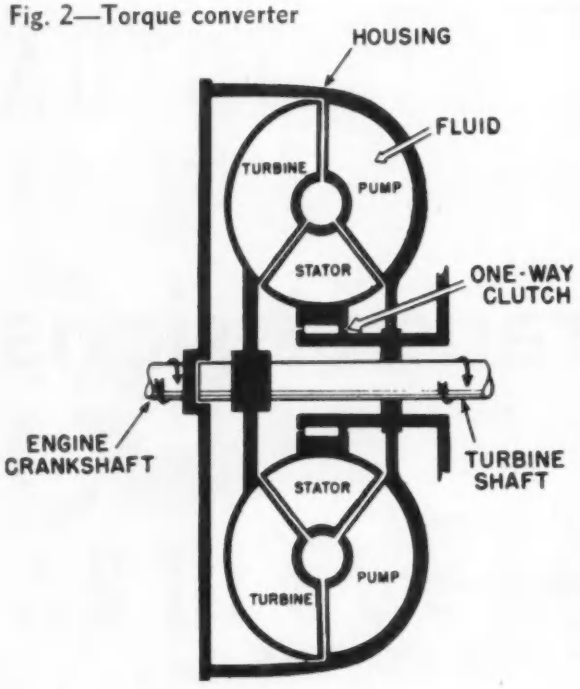


Fig. 3—Planetary gear set

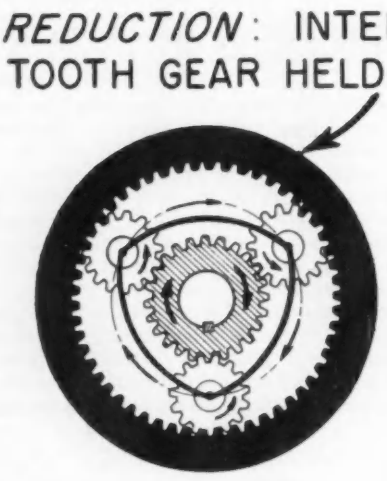
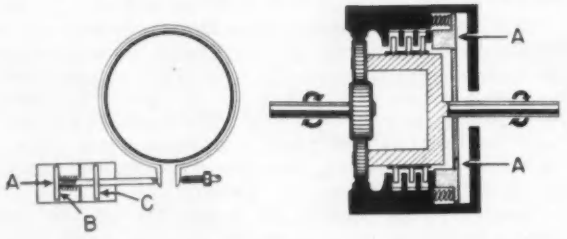


Fig. 4—Band and clutch



apply power to the sun gear, as shown in Fig. 3, the planet gears rotate and also walk around the internal tooth gear carrying the planet carrier with them. If the power is then taken off from the planet carrier we will have a substantial gear reduction.

If we apply power through the internal gear and we hold the sun gear, the planet gears rotate and walk around the sun gear.

If the power is taken out through the planet carrier we again have a gear reduction.

If we hold the planet carrier and apply power at the sun gear, the planet gears act only as idlers and they cause the internal tooth gear to rotate both at reduced speed and in a reverse direction.

In a typical gear set, the input shaft is attached to the planet carrier. The internal tooth gear is in the form of a drum. Interlocking clutch discs make it possible to lock the planet carrier and internal tooth gear together.

When this is done the whole unit locks together and turns as a unit. In other words it provides direct drive or 1/1 ratio. This would happen also if any other two components were locked together.

We have now shown that it is possible to achieve say, a 3/1, a 1.5/1, a direct drive forward, and say, 3/1 reverse by means of the planetary gear. It is not easy to provide all these controls on one set of gears, so in many transmissions two of them are placed in series rigged up to get maybe two reductions out of each.

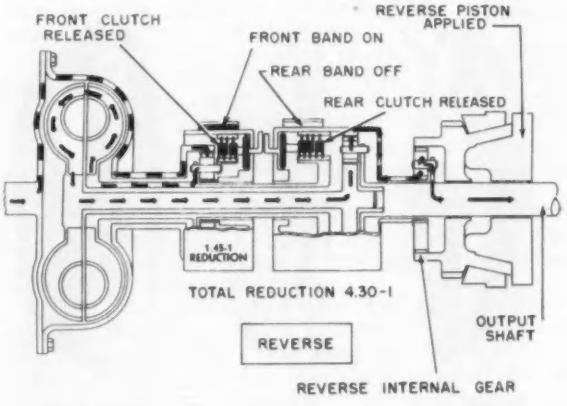
3. Bands and Clutches

The components of the planetary gear set are controlled by bands and by clutches.

At the left in Fig. 4 can be seen a circle representing the internal tooth gear and wrapped around it is a band similar to the brake bands of years ago. To control it, we have a small hydraulic cylinder usually called a "servo." There is a small spring to hold the band in the "off" position. To apply it we direct hydraulic pressure on a single piston at "A."

To release it quickly, when desirable, we are able

Fig. 5—Hydra-Matic in reverse



to apply the same pressure against two pistons—at "B" and "C."

At the right is the side view of a planetary set again and a clutch arrangement. Power comes in through the sun gear and goes out from the planet carrier. Loose interlocking clutch plates are splined alternately to the internal tooth gear and the planet carrier. When hydraulic pressure is applied at "A" on a large piston the plates are squeezed together and the unit is locked into direct drive.

What happens between the driver's lever or push button and these bands and clutches varies from one make of transmission to another. And it's a complicated process in each case. Suffice it to say that control is accomplished largely through hydraulic fluid and two classes of valves. One class regulates fluid pressure. The other directs the various streams of regulated fluid to the places where they are needed.

Actual Transmissions

The basic elements are combined into three main systems of transmission:

1. A **fluid coupling** in series with an automatic planetary gearbox. All of the torque multiplication is accomplished by the gearbox.
2. A **torque converter** in series with a planetary gearbox arranged so that in normal driving **all** of the torque multiplication is accomplished **by the converter.** The planetary gears are used only for low and reverse.
3. A **torque converter** in series with a planetary gearbox arranged so that for normal driving **part of the torque multiplication is accomplished by the gearbox and part by the torque converter.**

The **Hydra-Matic** is an example of the first type. Fig. 5 shows a simplified version of the Hydra-Matic in one of its early forms. The transmission is shown in reverse gear because in that condition every component is in action.

The power from the engine comes in at the shaft to the left. It goes up around the case, down to a hollow shaft, along that, and up to the internal tooth gear of the front planetary unit.

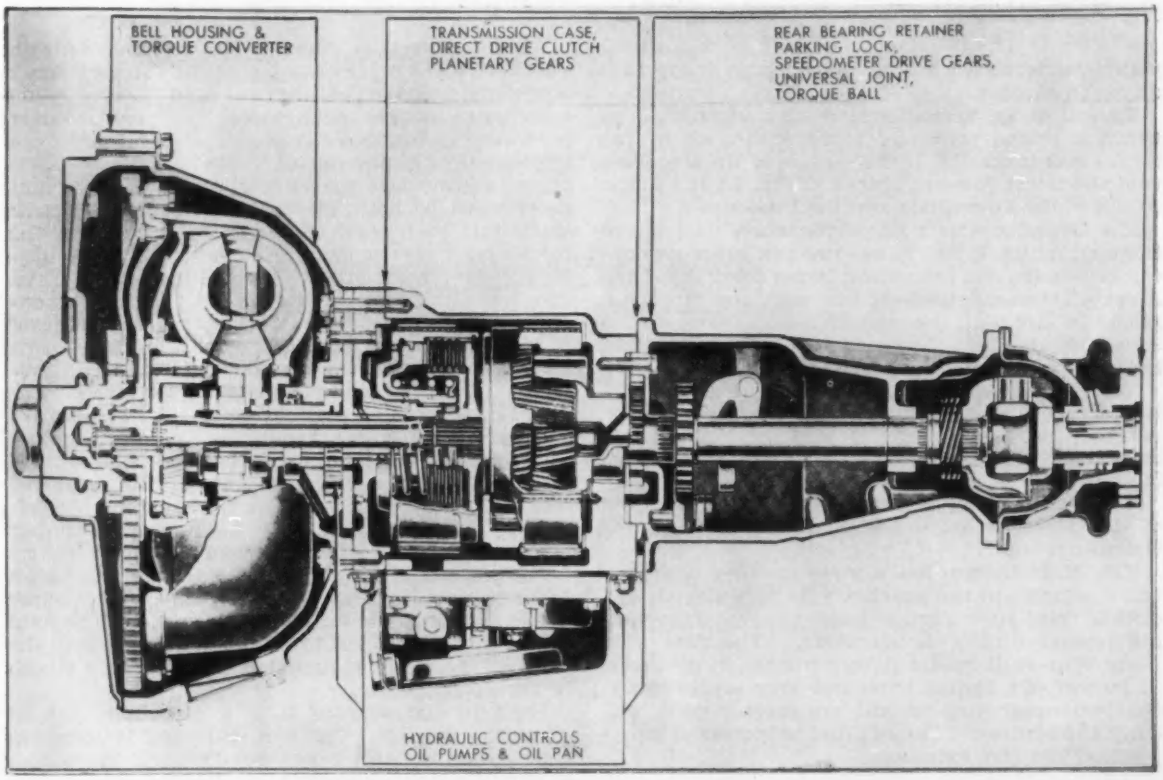
Notice that in this case the front band controls the sun gear rather than the internal tooth gear. The front band is on, so the sun gear is stopped. The power goes into the planet gears and thence to the planet carrier and back through a coaxial shaft to the driving torus of the fluid coupling, thence to the driven member and into the central shaft.

This arrangement of putting a ratio in ahead of the fluid coupling is to slow down the speed of rotation of the coupling before starting and thus reduce the tendency of the car to creep when in low gear.

The power now runs to the rear planetary unit. Since the rear band and rear clutch are both released—and the rear planet carrier resists rotation because it is attached to the output shaft—the power is transmitted in reverse direction through to the internal tooth gear and down to the sun gear of the reverse planetary set.

In this case the internal tooth gear is held and the power flows through the sun gears and out the

Fig. 6—Dynaflow


BELL HOUSING & TORQUE CONVERTER
TRANSMISSION CASE, DIRECT DRIVE CLUTCH PLANETARY GEARS
REAR BEARING RETAINER PARKING LOCK, SPEEDOMETER DRIVE GEARS, UNIVERSAL JOINT, TORQUE BALL
HYDRAULIC CONTROLS OIL PUMPS & OIL PAN

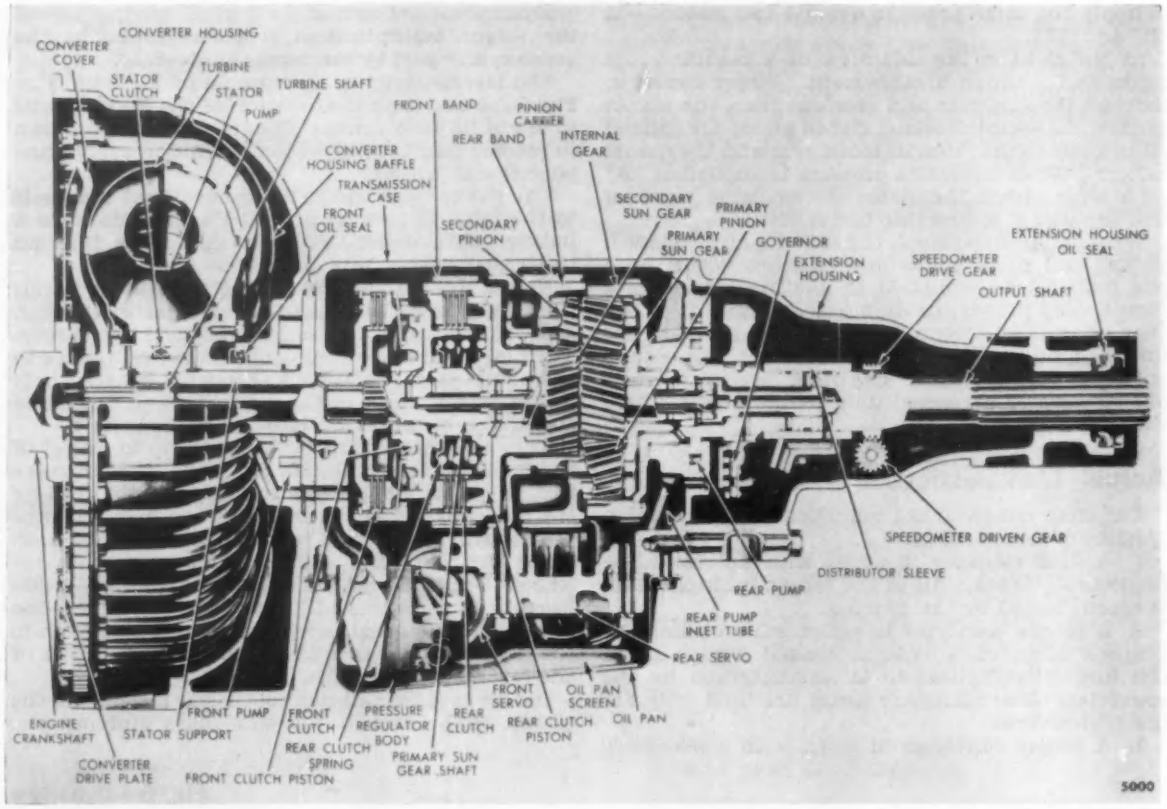


Fig. 7—Fordomatic

planet carrier to the output shaft, which of course is driven in reverse.

Typical of the second system of transmission, in which a torque converter accomplishes all of the torque multiplication, is the version of the **Dynaflow** (not the latest version) shown in Fig. 6. It's a first cousin of the **Powerglide** and the **Ultramatic.**

The Dynaflow has a single planetary gear set of the dual pinion type. It has two sun gears on concentric shafts, one gear being larger than the other. A set of three pinions meshes with the large sun gear and also with the smaller sun gear on the inside and with the larger pinions on the outside. Both sets of pinions ride on the same planet carrier.

This transmission gets all its torque multiplication for normal driving from the torque converter, except when low position is used for the take-off. To accomplish this a variable-pitch torque converter is used.

To trace the flow of power further, it comes out of the converter, on to the planetary unit and out the output shaft.

This transmission has a more complex converter but is simpler in the gearbox. Its very flexible hydraulic drive gives a much greater engine driveshaft differential during acceleration. The fact that there is no shift makes it very smooth in operation and a sort of a hydraulic passing gear is provided in that whenever you hit the accelerator pedal full down the blades are swung into the increased torque position and give extra zip.

The **Fordomatic, Merc-O-Matic,** and **Lincoln Turbodrive** are representative of the third category of transmissions in that they use both gear reduction —including a gear change—and torque converter reduction during acceleration. Fig. 7 shows the Fordomatic. In the normal drive position it starts off in intermediate gear and after reaching a point determined by both speed and throttle position it shifts into high gear. While this is happening the torque converter is changing over from full multiplication. Finally everything gets into direct drive.

A low gear is also provided, and this may be engaged for faster starting either by placing the lever at "low" or by leaving it at "drive" and depressing the accelerator all the way down. There is a "reverse" position and a solid "park" position. The gear ratios are 2.44/1 for low, 1.48/1 for second, 1/1 for high, and 2/1 for reverse.

Torque converter reduction is in the neighborhood of 2/1. Converters of 2/1 or less are often referred to as "mild" converters. Their torque transfer efficiency, when working at 1/1, approaches—but never quite equals—that of a straight fluid coupling.

Power comes in from the engine and through a flexible plate to the pump housing. The pump forces fluid into the turbine and drives it. The fluid passes into a simple stator which redirects it to the pump. The stator is mounted on a one-way clutch in the normal manner.

Back in the gearbox is a dual-pinion type of planetary gear set. This planetary unit is unique in that power is never taken out through the planet

carrier and therefore there is no band on the internal tooth gear.

After leaving the converter the power flows along a hollow shaft to the front clutch. It can pass through the clutch if it is applied and to the primary pinion of the planetary. Or if the clutch is not applied, then it can go on to the rear clutch, which locks in the secondary sun gear.

These clutches and bands produce first, intermediate, and third gears and reverse. For example, when both clutches are applied and both bands released, the whole planetary set is locked and the drive is straight through.

Some other features are a gear and pawl arrangement for parking and a front and rear oil pressure pump mounted concentrically around the shafting.

A device which is midway between the two extremes of the design range can either combine the best points or the worst points of both schools of thought. It is Ford's contention, you may be sure, that the best points only are incorporated.

The torque converter does tend to cushion the change of ratio and a series of valves modulate and compensate the application oil pressures, so that all of the shifts going both up and down are soft and without jolt. There is, of course, a passing gear which gets the transmission back into second and is highly effective at moderate speeds.

Another transmission in the third category is the Chrysler **Power Flite**, shown in Fig. 8. It relies more on the torque converter for torque multiplication than does the Fordomatic. It has a 2.60/1 torque converter and just two forward gears and a reverse. However, it engages first gear on every forward start and makes a shift at some speed proportional to throttle opening and speed.

As shown at the left in fig. 8, the Power Flite has a simple four-element torque converter.

In the gearbox proper there are two simple planetary sets controlled by two band applications and one clutch. The power always flows out through the internal toother gear of the rear clutch.

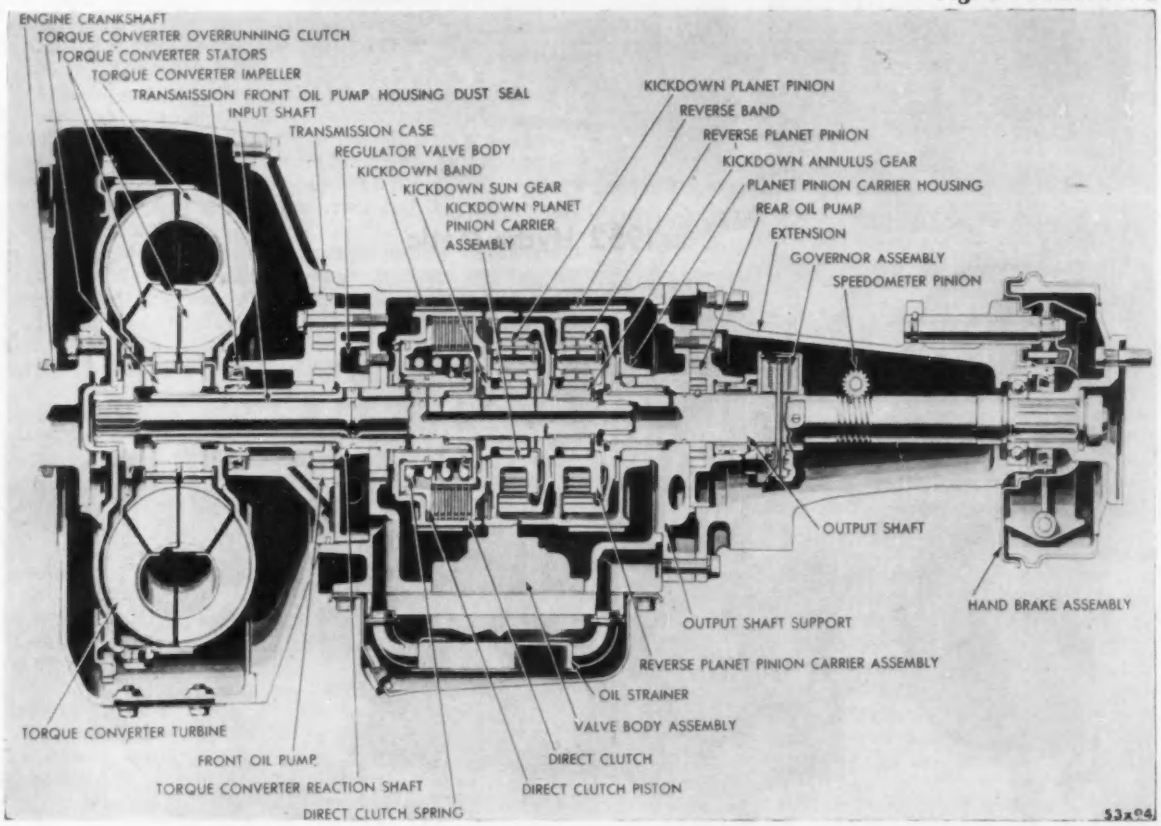
There is no parking gear or pawl in the rear gear area because the producers feel that the powerful parking brake on the output shaft is a more desirable arrangement.

The Power Flite transmission is notable for its simplicity both in construction and in operation, and for the fact that there is a very generous use of aluminum throughout. The big converter housing and the stator are good examples of aluminum castings. Overall available ratio is 4.5/1 through the system as against figures between 5 and 6 for transmissions that have a low gear. There is a "low" position on the quadrant, of course, and its action is to hold the unit in first gear position.

The **Studebaker Automatic Transmission** is very similar to the Power Flite except that it has a dry clutch mounted in front of the converter so that it can be locked solidly in high. **Ultramatic** also has this feature.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

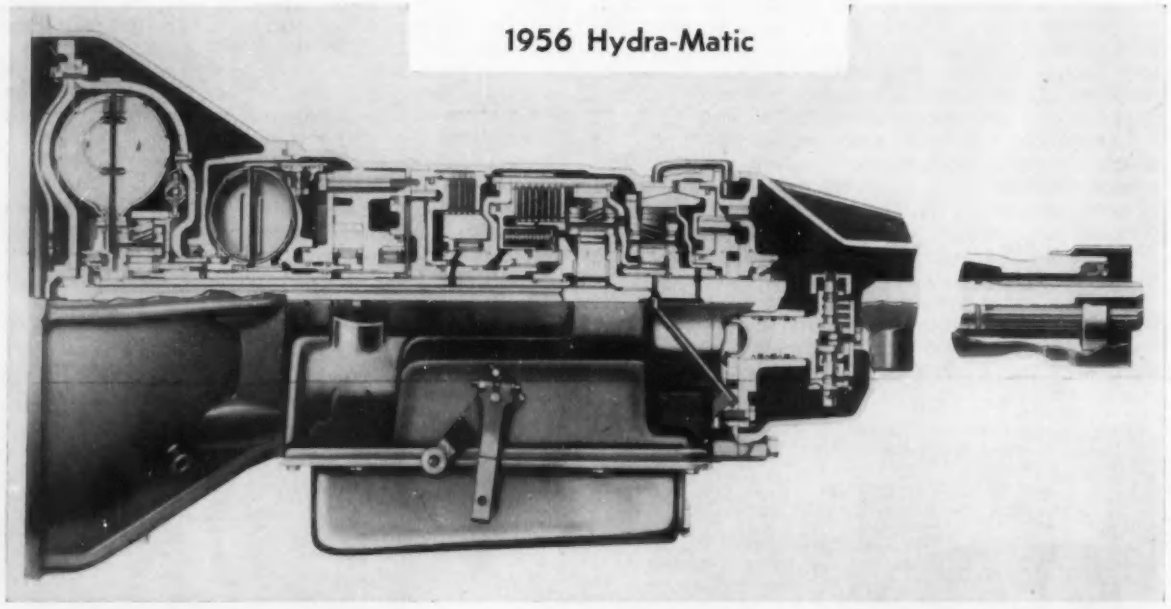
Fig. 8—Power Flite

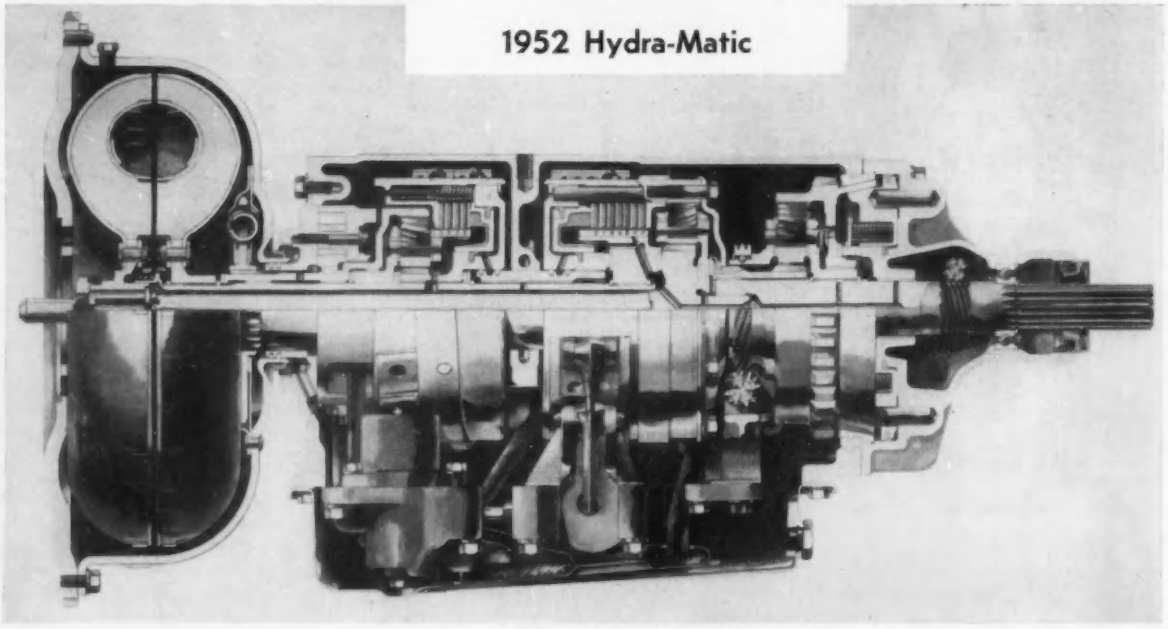


Kenneth W. Gage, Chief Engineer and
P. J. Rhoads, Assistant Chief Engineer, Detroit Transmission Division, GMC

Excerpts from paper "The New General Motors Hydra-Matic Transmission" presented at SAE Annual Meeting, Detroit, Jan. 12, 1956.

What's New About the





This is the 2nd of 7

AUTOMATIC TRANSMISSION ARTICLES appearing in this issue.

1956 Hydra-Matic

is its small fluid coupling replacing the multiple-plate clutch and its one-way sprag clutch replacing the reaction band in the front unit. Aim is to combine smoother shifts with Hydra-Matic's traditional good economy and performance.

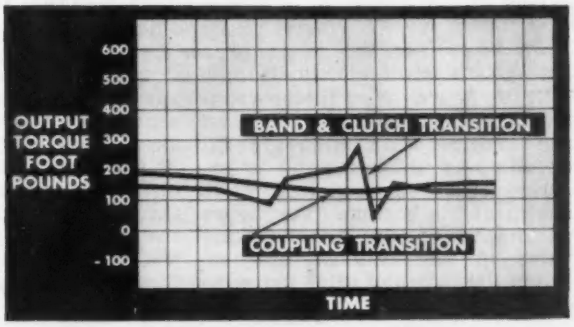
THE fundamental principles of the 1956 Hydra-Matic remain the same as those of earlier Hydra-Matics. The new transmission still consists of a fluid coupling with three planetary gear sets providing four even stepped forward speeds and reverse. The dual range principle which found favor on the 1952 Hydra-Matic was retained, along with the fluid coupling split torque hook-up which allows good economy characteristics.

While these basic fundamentals remain the same, the methods of acquiring the ratios have been completely revised. Almost every part in the transmission has been redesigned. The result is smoother operation and the greater capacity required by projected engines in a package arranged for projected body designs.

The basic engineering concept which made the 1956 Hydra-Matic possible was substitution of a small fluid coupling for the multiple-plate clutch and a one-way sprag clutch for the reaction band in the front unit. The action of filling a coupling to lock a planetary gear set in the direct drive by picking up a sprag clutch is basically much smoother than the action of the band and plate clutch. If a band-to-plate clutch shaft is not timed properly, it is possible to get either a neutral condition or a tie-up between the clutch and band during the shift. In the 1956 Hydra-Matic, the fluid coupling smoothly picks up the reaction sun gear of the front unit from the one-way sprag clutch without any possibility of either neutral or tie-up.

Results of this type of shift can be more easily seen from a comparison of the output torque characteristic of the transmission during the shift time. In Fig. 1 you can see from the two curves the marked difference in torque change during a front unit upshift transition.

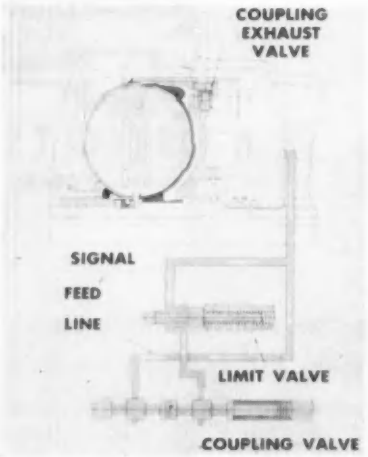
Due to the method of tying the gear set together for direct drive, the coupling is required to hold only 0.356/1 engine torque as compared to 1.556/1 engine torque for the large coupling. This made the project feasible because the front unit coupling could be made small enough to be practical.



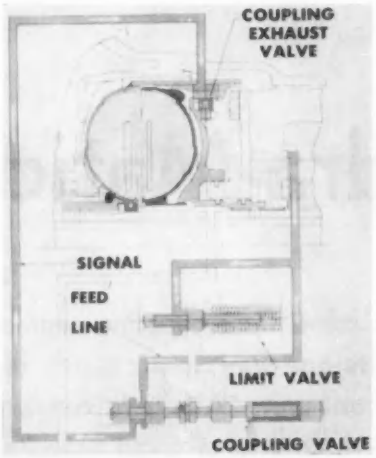
COUPLING'S SMOOTH TORQUE CURVE shows why 1956 Hydra-Matic gives much smoother third-to-fourth gear transition than did band and clutch of earlier Hydra-Matics.

Since a completely new transmission was required to incorporate all of the new features, it was decided to review the 1955 Hydra-Matic with the idea of incorporating such design features as would help our customers as well as our own manufacture. Previous to the 1956 Hydra-Matic all large fluid coupling parts have been shipped separately. It was decided to design the new transmission as a package unit which would use a flex-plate drive to facilitate installation and removal from the car. In order to provide floor board clearance and facilitate service, the valve body and side cover were removed and the valve body was installed in the bottom pan. Because of our many customers, it was decided to split the bell housing and case to provide a common case and separate bell housings to fit the customers' individual needs.

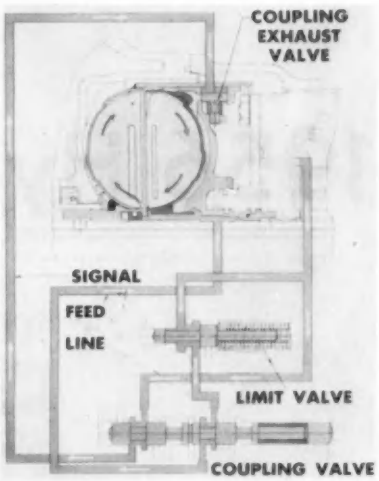
As the cross-section illustration at the left shows,



Coupling empty
Coupling valve in exhaust position



Coupling about to be filled
Coupling valve directs oil to close coupling exhaust valves



Coupling filling
Coupling exhaust valve is closed
Limit valve directs line pressure through coupling valve to fill coupling

These figures show the environment of the controlling valves and the small coupling. Signal for fill or dump of this coupling is received from the coupling valve shown at the bottom. The figure at the left shows the coupling valve in the exhaust position. When the coupling valve moves to the fill position, shown in the center figure, oil is first directed to close the coupling exhaust valves. At the same time, line pressure is directed through the limit valve through the coupling valve to fill the small coupling, as shown at the right. The limit valve insures that the coupling exhaust valves are closed before the coupling itself is filled. When the coupling is dumped, the coupling valve moves to exhaust position which closes off flow to the coupling and exhausts oil from the top of the coupling exhaust valve. This allows the exhaust valves to move out, dumping the coupling.

the drive from the engine goes into the internal gear of the front gear set, which in this transmission has been installed in the large fluid coupling cavity.

The large fluid coupling receives its drive from the carrier of the front unit gear set. Reaction of the front unit is through the sun gear which is locked through the front unit sprag assembly to ground.

As the front unit coupling is filled, the fluid drive picks up the sun gear through the driven member of this coupling to take the torque reaction of the front unit as a direct ratio. The action of the coupling fill is illustrated above.

The same type of variable-capacity front pump, with a greater capacity, is used in the 1956 transmission as has been used since 1952. This pump is of the variable-capacity vane type. Due to the large demand during time of filling the coupling, the variable-vane type of pump is the only practical pump to use in this application. A constant-displacement pump, if used in this application, would pump too much oil when not needed to fill the coupling. This would create larger pumping losses than necessary and the problem of handling the excess oil.

Attached to the inner sprag race of the front unit is a single-plate clutch which is used only in Drive 3, low and reverse to take overrun reaction of the front unit sprag assembly. This plate is not used in any ratio in Drive 4 range.

In the rear unit assembly, reaction for the reduction ratio is taken by the internal gear through another one-way sprag clutch to ground. Neutral is obtained in the transmission by making and breaking the reaction of the rear unit sprag assembly by means of a multiple-plate clutch. A band is used in conjunction with the rear unit only for overrun braking in low gear.

It can be seen from this description that three out of four friction elements in the 1955 Hydra-Matic have been replaced with one-way clutches and a fluid coupling in the 1956 Hydra-Matic. Since the front unit coupling is either exhausted or filled on every shift it allows inherently smoother timing of

the shifts than was possible before. The third gear set is used for reverse only, and reaction for the internal gear is taken through a cone clutch.

In the 1955 Hydra-Matic a cross-drive rear pump and governor assembly was used. In the 1956 transmission, the drive gear of the rear pump is coaxial with the output shaft and drives the driven gear of the pump which in turn drives the governor. Access to the governor is easily gained by removing or backing off the rear bearing retainer.

Schematic diagrams on this and following pages show the power flow of the 1956 Hydra-Matic.

In addition to the 1955 shift sequence of Neutral, Drive 4, Drive 3 or S, Lo, and Reverse, a new position of Park has been added to the left of the Neutral position. This allows the car to be started in either Park or Neutral and is a positive Park with the engine running.

In addition to giving excellent control of all forward driving conditions through throttle control of the shift points in Drive 4 Range, additional dual range controls have been retained. The Drive 3 or Super Range with its top third gear and Lo with a top second gear give excellent over-all control of the vehicle. The third gear range can be used not only for mountain highway running, but also as an additional braking feature when the vehicle needs to be slowed down from high speed. For example when the driver approaches a car going in the same direction and has to slow down prior to passing, Drive 3 Range is an excellent range for braking as well as for passing when the road is clear.

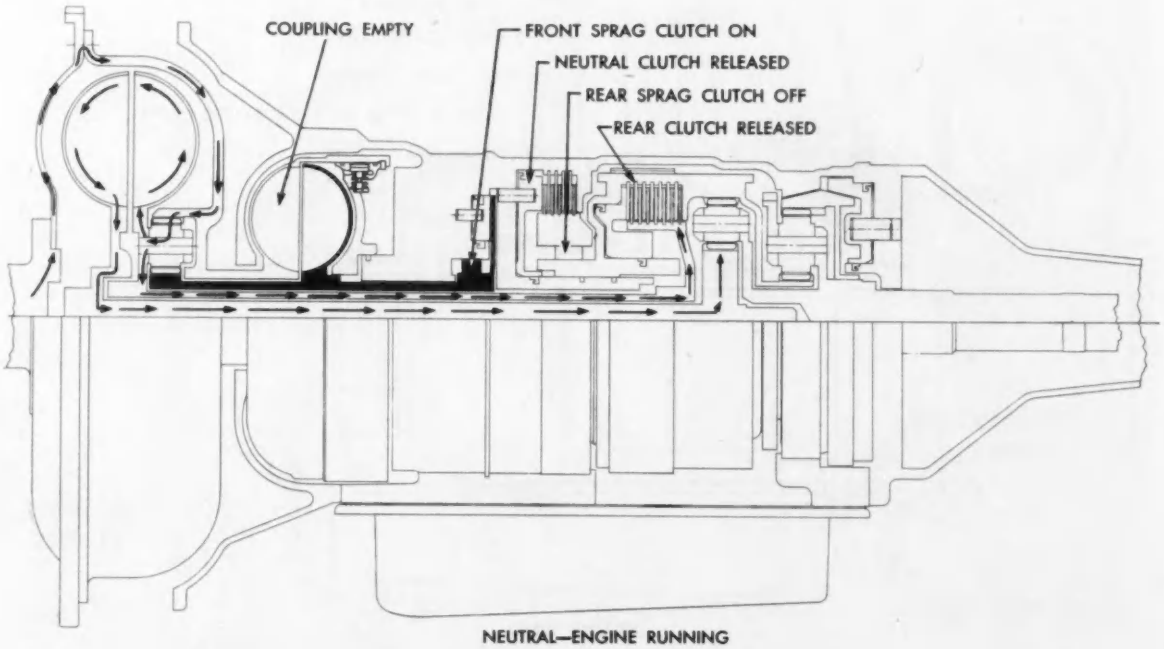
Both Drive 3 and Lo Ranges as well as Reverse are inhibited. Drive 3 is inhibited above 65 to 70 mph and Lo above 40 mph.

The inherent smoothness of the front unit coupling control has led to better performance under city driving conditions. Because of this smoothness, it was possible to raise the part-throttle fourth-to-third downshift to 30–40 mph, thus giving better performance under part-throttle condition. Full throttle fourth-to-third detent downshifts to 65–70 mph and third-to-fourth upshifts at 70–80 mph retain the excellent high-speed passing ability of the Hydra-Matic with the additional feature of imperceptible shift smoothness.

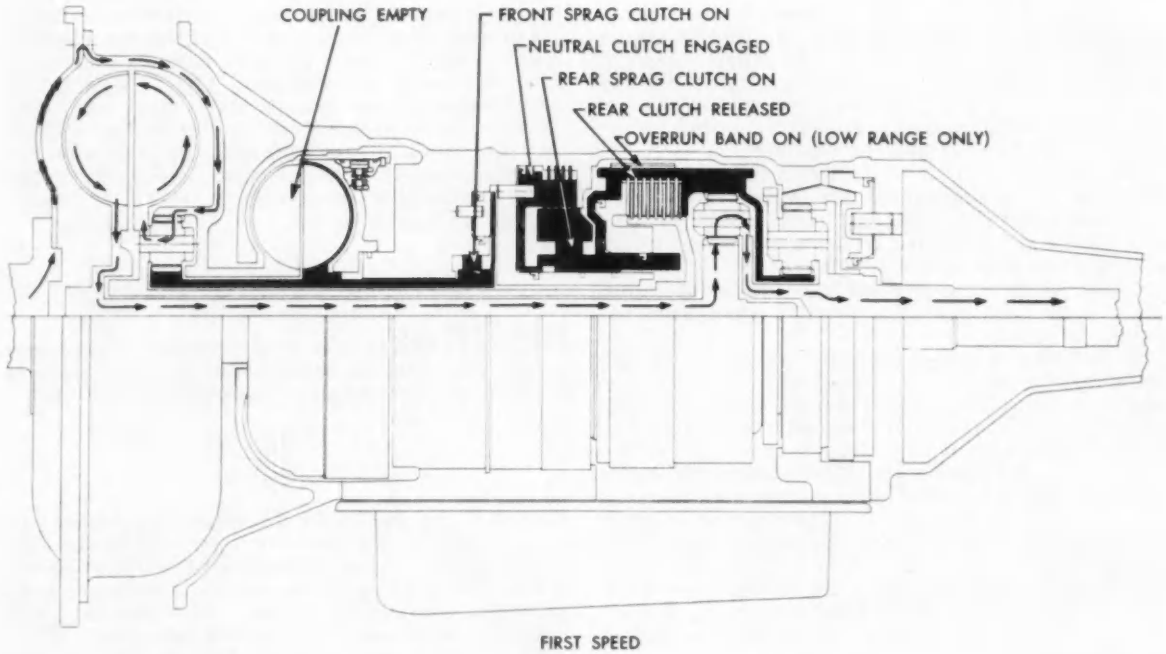
NEUTRAL Power to the rear wheels is broken in the transmission because the neutral clutch is released, allowing no drive through the rear unit.

FIRST In the 1955 Hydra-Matic both bands had to be applied to get first-gear reaction. In the 1956 Hydra-Matic, the neutral clutch only has to be applied. The front unit is in reduction with the sprag grounded and coupling empty. The rear unit is in reduction with rear sprag on and rear clutch off.

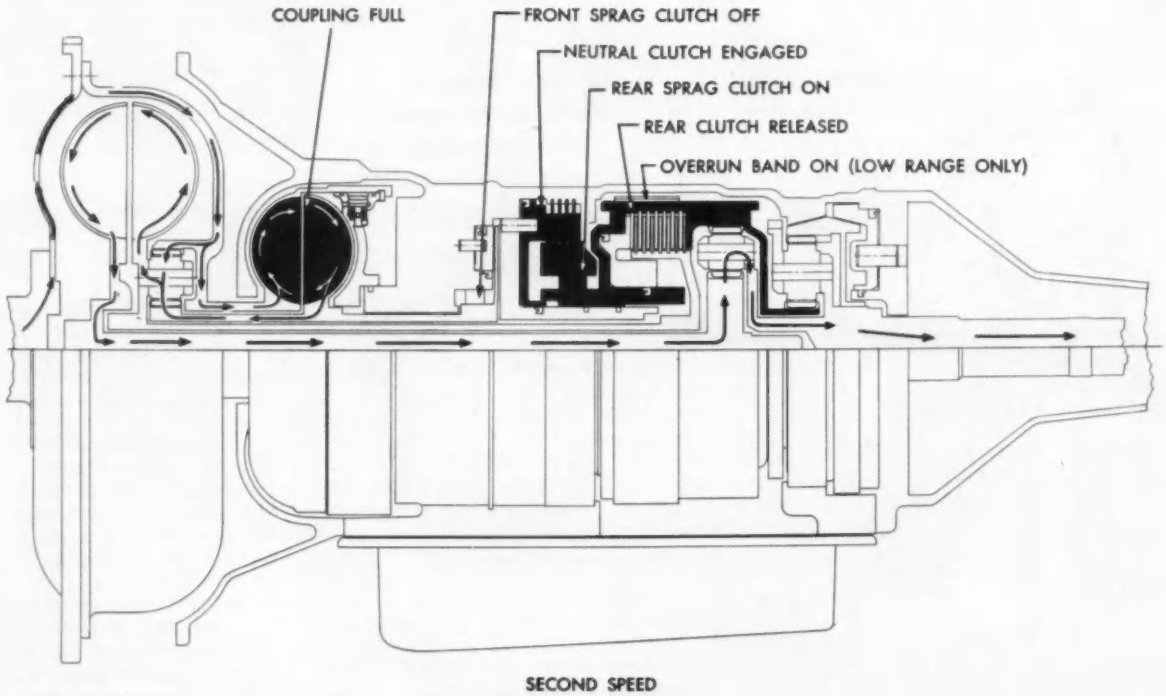
The power flows mechanically from the flywheel to the torus cover and to the front unit internal



NEUTRAL—ENGINE RUNNING



FIRST SPEED



SECOND SPEED

gear which is attached to the torus cover. Power is directed through the internal gear to the front unit carrier assembly. The sun gear is held by the front sprag assembly, and the carrier rotates around the sun gear at a slower rate or 1.55/1 reduction. The front unit carrier is attached to the large drive torus member. In turn, the driven torus member drives the connected main shaft and rear unit sun gear. Since the internal gear is grounded by the rear unit sprag assembly, the rear unit sun gear drives the rear unit carrier at a reduced speed or 2.55 reduction. The carrier of the rear unit is attached to the output shaft, and power will be directed from the carrier through the output shaft. The transmission is now in first speed. The rear unit reduction of 2.5532/1 times the front unit reduction of 1.5536/1 equals a 3.966/1 reduction.

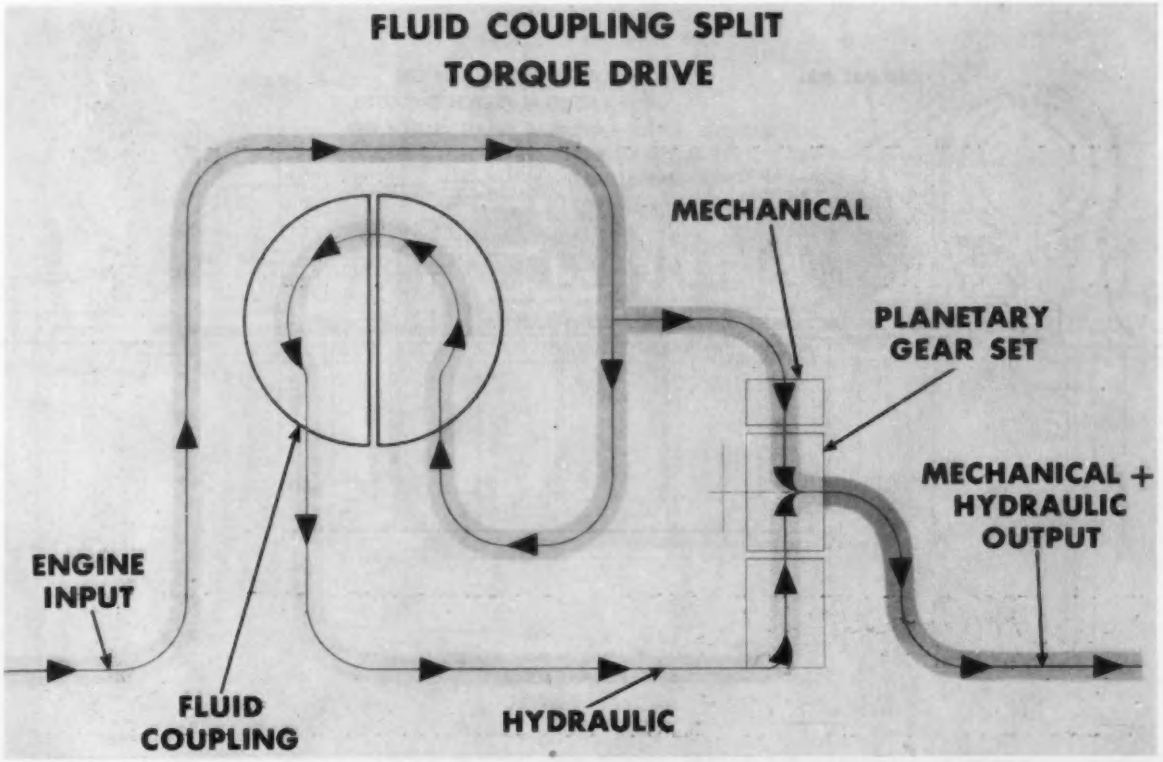
SECOND The coupling is filled hydraulically, picking up the reaction of the front unit sun gear. Now the front unit is in direct drive with the sprag off, coupling full. The rear unit is still in reduction with the sprag on and the rear clutch off. Power flows mechanically from the flywheel to the torus cover and to the front unit internal gear which is attached to the torus cover. It also flows hydraulically through the front unit torus assembly to the sun gear. Thus through the split torque principle the planetary gear set is locked together (internal gear and sun gear) through the front unit torus assembly, which creates a 1/1 ratio in the front unit. The ratio of split torque drive is 0.356 hydraulic and 0.644 mechanical.

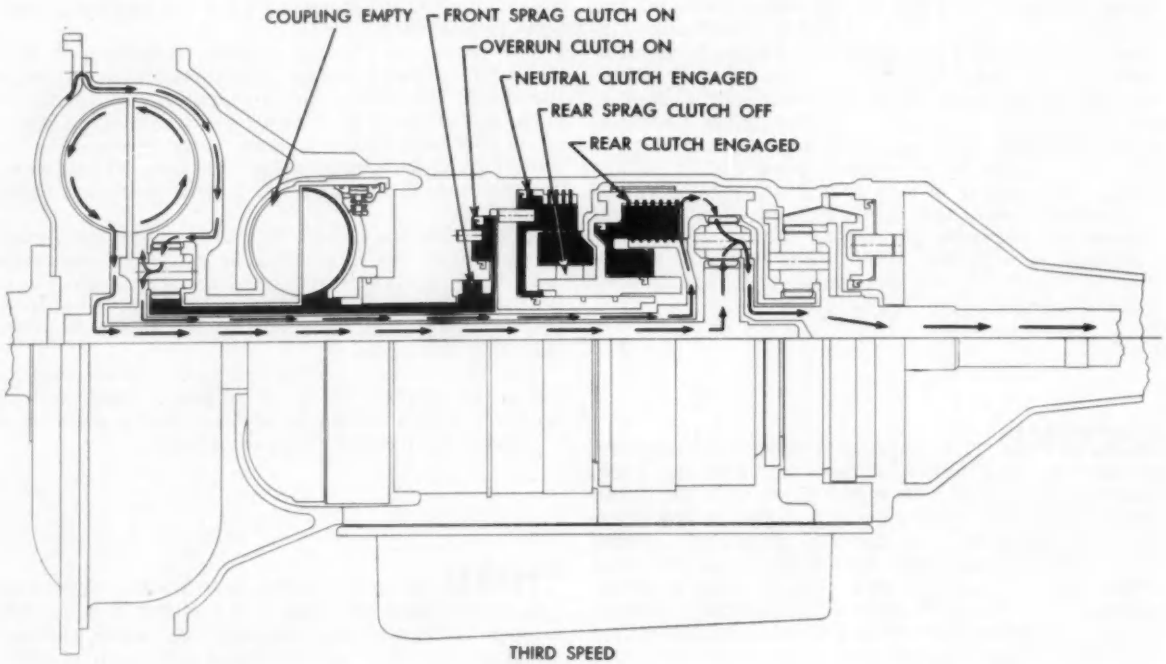
The front unit planet carrier, attached to the large drive torus member, transmits torque through the oil to the driven torus member. In turn the large driven torus member drives a connected main shaft and rear unit sun gear. The rear unit is in reduction as was described in first gear. The transmission is now in second speed with reduction ratio of 2.5532/1.

As the diagram shows, the input splits; part goes mechanically through the ring gear and part hydraulically through the coupling to the sun gear. Both combine to give a 1/1 ratio of input to output torque while allowing a cushioning effect through the torus assembly.

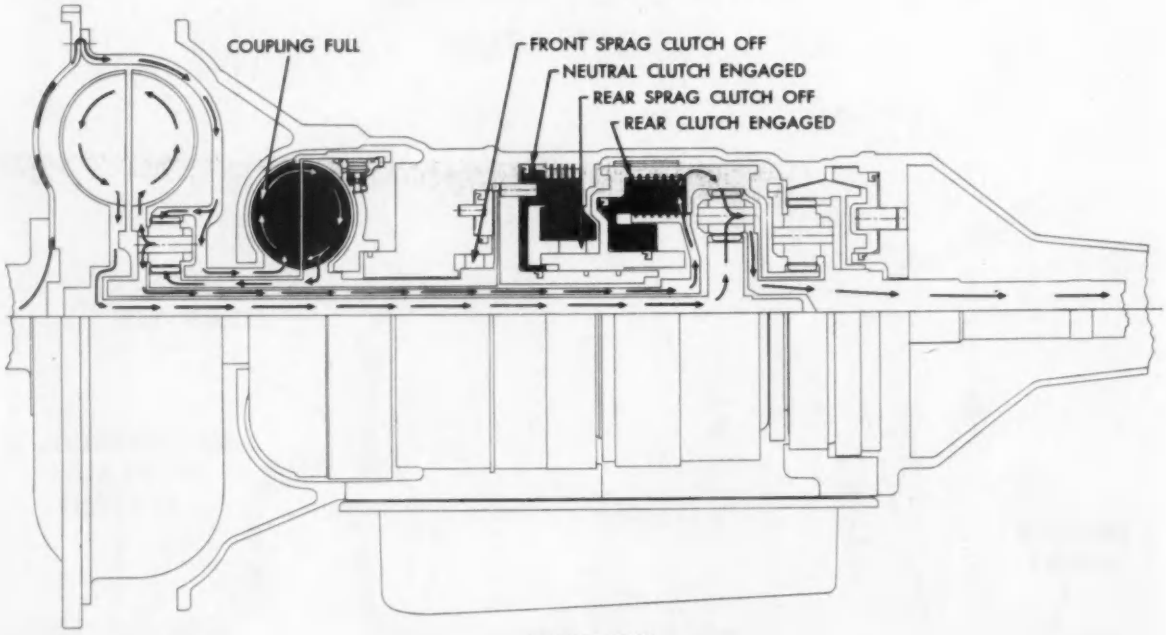
This is the same split torque principle as used in the earlier Hydra-Matic. It allows a maximum of economy with a minimum of slip. At the same time it gives a cushioning effect to all shifts.

THIRD To obtain third gear we use the front unit in reduction and rear unit in direct drive. This is accomplished by applying the rear clutch and exhausting the front unit coupling, which means the





THIRD SPEED



FOURTH SPEED

front unit sprag is grounded and the coupling is empty; the rear unit sprag is off and the rear clutch is on. Power flows mechanically from the flywheel to the torus cover and to the front unit internal gear, which is attached to the torus cover. Power is directed from the internal gear to the front unit carrier assembly as the front unit sun gear is grounded by the front sprag assembly.

When the rear clutch is on power divides to the front unit carrier assembly and is directed to the rear unit in two ways:

Fluid—The front unit carrier is attached to the drive torus member and will, through oil, drive the driven torus member. In turn the driven torus member drives the connected main shaft and rear unit sun gear.

Mechanical—Power is directed mechanically from the carrier of the front unit to the rear unit through the intermediate shaft which is splined to the large drive torus member. The intermediate shaft is splined to the rear clutch hub.

The rear clutch is applied and power is transmitted through the clutch plates, drum, and rear internal gear to the planet pinions, where it combines with the power from the rear unit sun gear. The split torque ratio under these conditions is 60% mechanical and 40% hydraulic.

The carrier of the rear unit is attached to the output shaft and directs power to the rear wheels. The transmission is now in third speed with reduction in the front unit of 1.5536/1.

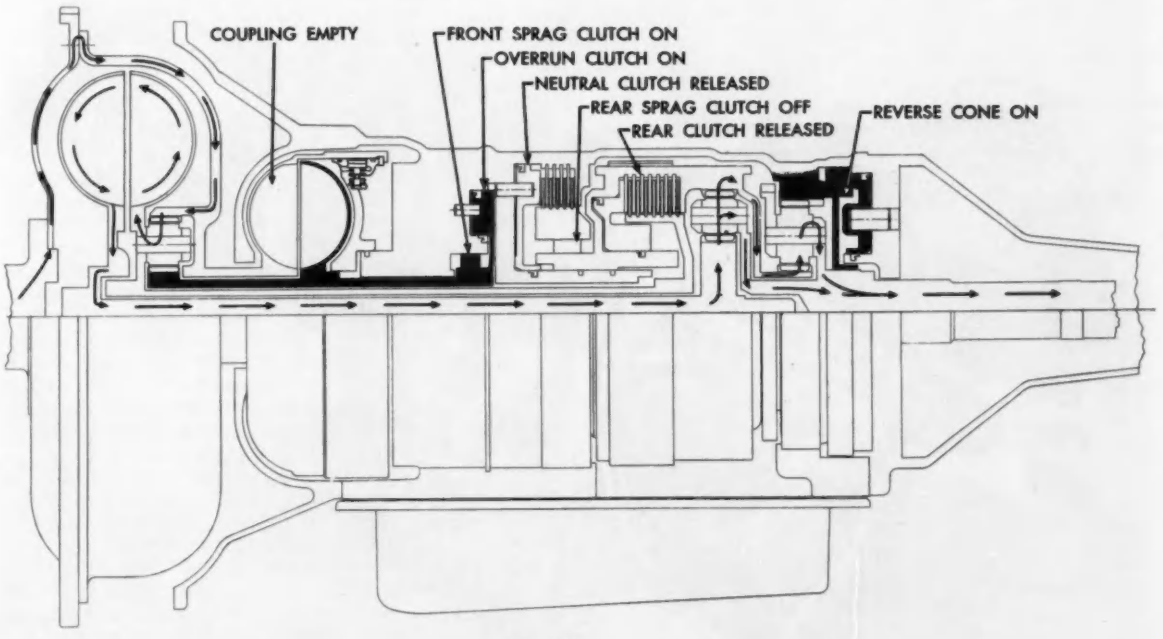
FOURTH During the shift from third to fourth gear, it is only necessary to fill the front unit coupling. The rear unit is already in direct drive, and filling the front unit coupling puts it into direct drive which gives a transmission ratio of 1/1.

REVERSE In reverse, the front unit is in reduction with the sprag on and coupling empty. The reverse gear set is in reduction with the internal gear grounded by means of a cone clutch, and the rear unit gear set is compounded with the reverse gear set.

Drive is through the reduction of the front unit through the large torus assembly to the rear unit sun gear. Since the rear sprag is released, the sun gear of the rear unit will drive the rear internal gear counterclockwise or reverse. The internal gear, through a flange, will drive the center gear of the reverse unit counterclockwise. Power then travels through the reverse planetary carrier to the output shaft in reduction because the internal gear is grounded by the reverse cone clutch.

The transmission is now in reverse with a 4.307 reduction.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.



REVERSE

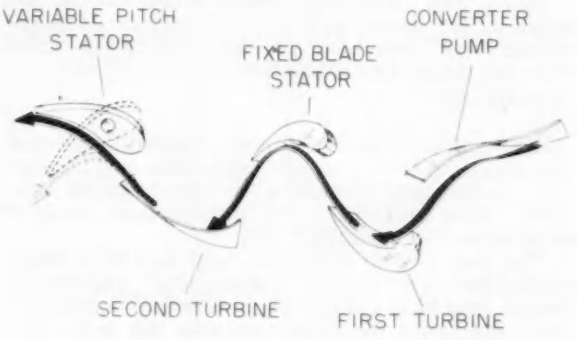
This is the 3rd of 7

AUTOMATIC TRANSMISSION ARTICLES

appearing in this issue

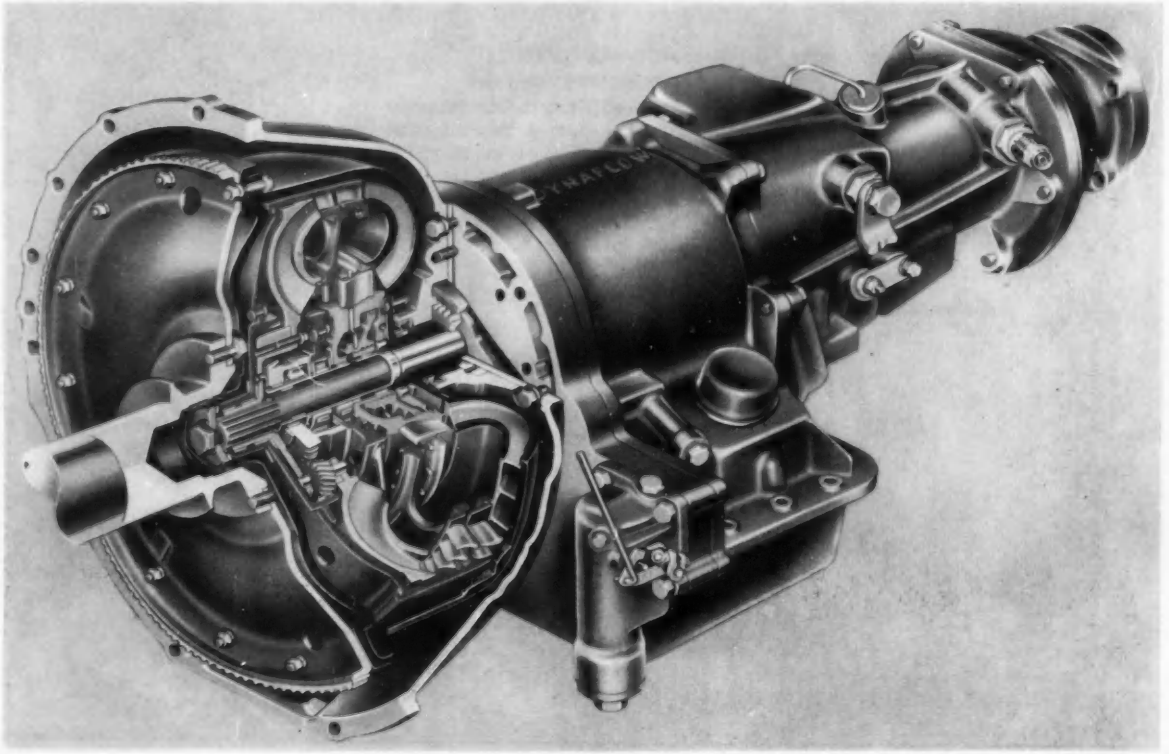
What's New About the

. . . is that a fixed-blade stator has been added between the first and second turbines. . . . Also the transmission has been revised to save money on materials and manufacture.



TO improve transmission performance at low engine speeds still further over the 1955 and earlier Dynaflow transmissions, a fixed-blade stator has been added between the first and second turbines.

This gives the 1956 Twin Turbine Dynaflow a pump, two turbines, one fixed-blade stator, and one variable-pitch stator. The original dynaflow torque converter consisted of a primary pump, a secondary pump (which was mounted on an overrunning clutch), a turbine, and two stators (which also were mounted on overrunning clutches). It was, in a sense, three torque converters and a fluid coupling



R. J. Gorsky, Buick Motor Division GMC

Based on paper "The New Dynaflow Automatic Transmission" presented at SAE Annual Meeting, Detroit, Jan. 12, 1956.

1956 Dynaflow . . .

combined into a single unit. This resulted in four sets of curves, the most desirable portions of which were utilized.

To improve the car performance and converter efficiency, and to reduce the engine speed for a given car speed, the Twin Turbine Dynaflow Transmission was introduced on the Buick 1953 models.

This design utilizes the torque multiplying characteristics of a planetary gear set in conjunction with the torque multiplying ability of a hydrokinetic torque converter and retains the smooth, uninterrupted power flow, characteristic of a fluid torque converter. The arrangement of the Twin Turbine Dynaflow torque converter is unique in that all the power transferred is through the gear set and first turbine at low speeds. The torque gradually and smoothly diminishes as the second turbine torque increases until it does all the work at higher speeds.

The converter pump is driven by the engine and energizes the converter fluid. The first turbine receives the fluid leaving the pump and drives the planetary ring gear through a disc member which is riveted to the ring gear. The second turbine is doweled and bolted to the planet carrier which in turn is splined to the converter output shaft. The stator is mounted on an overrunning clutch which is common to it and to the planetary sun gear.

In the 1955 Dynaflow, Buick introduced a converter having a variable-pitch stator blade. This converter is similar to the one used during the 1953 and 1954 model years. The principal revision was in the stator, changing from a fixed-blade member to a variable-pitch blade assembly. By controlling the pitch of the stator blades, the best angle for cruising and economy can be obtained as well as the best angle for performance. With the fixed-stator blade, a compromise angle had to be used.

The 1955 transmission had two completely different sets of characteristics. From the combination, engine speed at low angle was reduced, efficiency was improved, and the torque ratio or performance was increased (at high stator blade angle).

The developed view above of the converter element blades shows how the changing direction of oil flow through the converter imposes forces on the various elements. The pump member energizes the oil and causes it to flow to the first turbine member. Here its flow direction changes from the entrance end to the exit end of the blade, causing a driving force to be imposed on this member. This driving torque is multiplied by the converter planetary gear set before it is fed into the converter output shaft. The fixed-blade stator member then redirects the oil flow so that it will enter the second turbine member at an angle which will provide a driving torque to this member. The second turbine is splined directly to the converter output shaft and transmits torque supplementing the first turbine torque during acceleration. At higher car speeds and at cruising the second turbine transmits all of the driving force.

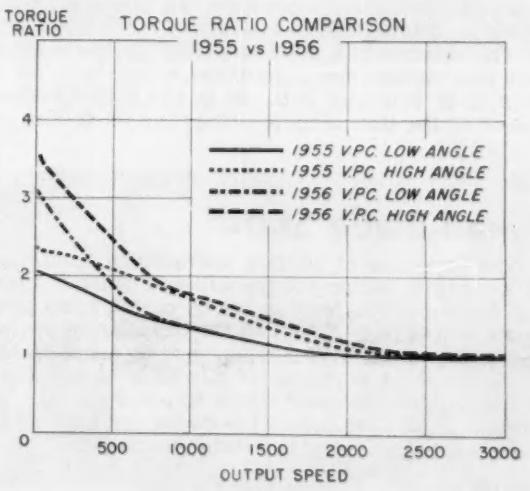
The oil leaving the second turbine then enters the variable pitch stator, where it is redirected before re-entering the converter pump member to repeat this cycle. The magnitude of directional change is greater at high stator blade angle than at low, which results in more converter ratio or car performance.

The diagram above shows the flow at a stall condition in which all members except the pump are stationary. The direction of oil flow changes as the power being transmitted and the car speed vary. This causes the turbines to increase in rotational speed and the stators to start overrunning.

This change in oil flow can be illustrated by the vector diagrams on the next two pages.

Under normal acceleration and cruising, the stator vanes of the variable-pitch stator will be in "low angle," or nearly parallel to the centerline of the converter. This provides the largest opening between the vanes for freedom of oil movement through the stator and a minimum amount of redirecting of the converter oil flow. The "low angle" position gives less engine speed and more efficient converter operation.

Under performance operation, the stator vanes will be in "high angle," or like a venetian blind partially closed. This provides the greatest redirecting of the converter oil flow and a resultant higher converter torque ratio. It also permits the engine speed



to increase so that more power is developed.

In this manner the driver can adjust the converter to better meet his driving conditions. The stator piston moves in response to oil directed from the stator control valve. This control valve is operated mechanically by linkage from the throttle control mechanism. An added resistance at the end of throttle pedal movement is used so that the driver will realize that further movement will put the transmission into performance range.

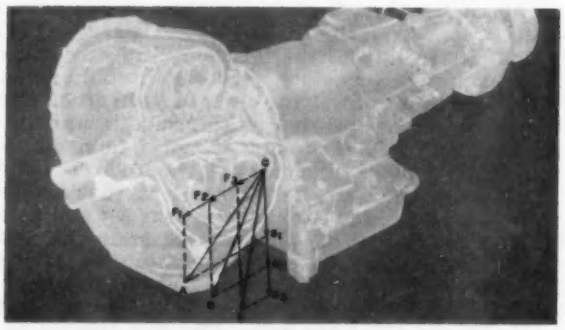
The transition from cruise performance to full-throttle performance is very smooth because it is accomplished by changing the converter oil flow instead of by shifting clutches and bands. The increase in performance from low vane angle to high vane angle is greatest at low car speeds and gradually diminishes as the converter coupling range is approached. This provides a safety feature to overtake

Vector Diagrams for the Elements of

Pump

With a low member speed, as shown by S_1, and a high vortex flow, as shown by F_1, the vector sum will be *O-A*. With a high member speed, S_3, and a low vortex flow, F_3, the vector sum will be *O-C*.

The pump operates like a simple centrifugal pump, and the absolute velocity of the fluid will be the vector sum of the circumferential speed S_1 of the pump blade which drives the fluid, plus the linear speed F_1 of the fluid in relation to the blade. As the car speed increases the fluid flow decreases; the vector sum will change in direction and magnitude as shown by vectors *O-A*, *O-B*, and *O-C*. Because of its mass and velocity, this fluid contains energy, which it obtained from the engine.

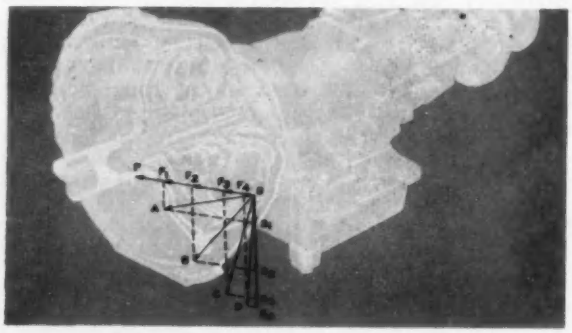


First Turbine

When a converter element changes the direction of flow, this member will have a force imparted to it. A vector diagram showing the oil leaving the first turbine blades will show the amount of directional change of the oil flow and will consequently indicate the force imparted to this member.

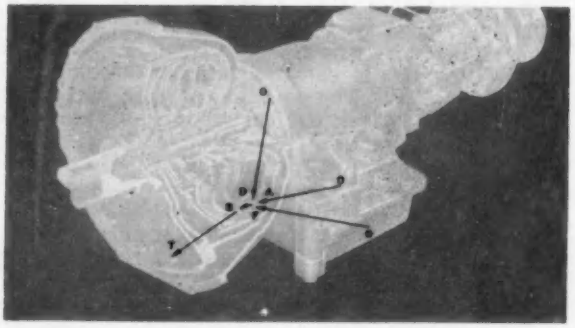
At stall the turbine speed is zero; the direction of oil flow will be tangent to the exit end of this blade as shown at *F*. This results in the largest change in direction between the entering oil and the leaving oil. Consequently, it produces the greatest driving force on this member.

The difference in directional change decreases as the first turbine speed increases, which is shown by *O-A*, *O-B*, *O-C*, and *O-D*. At *D*, the high rotational speed of the first turbine causes the oil to flow between its blades without being changed in direction. At this point it is delivering no torque and the second turbine blades do all the driving.



Fixed-Blade Stator

The direction of oil flow leaving the fixed-blade stator will be tangent to the exit end which is shown by vectors *S-T* as long as the oil enters at an angle such as *O-A* or *O-F*. When the direction of oil flow leaving the first turbine changes to an angle such as *O-D*, the fluid impinges on the back of the stator blade and the member starts to overrun. The direction of oil flow leaving the stator will then be the same as that entering the stator, namely *O-D*.



other vehicles by "switch the pitch" performance.

With the addition of the fixed-blade stator, the stall ratio has been increased from 2.1:1 to 3.2:1 for low stator blade angle and from 2.4:1 to 3.5:1 for high stator blade angle. The graph on page 51 shows the improvement in performance.

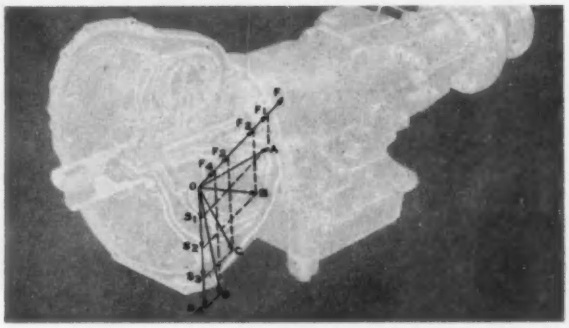
The length and direction of the vector sum, or absolute velocity of the oil, will change as the conditions vary. (The vectors shown below are for purposes of illustration and do not necessarily represent true values.) The absolute velocity of a particle of oil will be the vector sum of the velocity of the converter member it is leaving, which will be a tangential vector, plus the vortex velocity of the oil in relation to the blade it is leaving. The latter will have a direction parallel to the exit end of the blade. If the member is stationary, the absolute velocity will be the same as the vortex velocity.

CONTINUED ON NEXT PAGE

the 1956 Dynaflow Transmission

Variable-Pitch Stator, Low Pitch

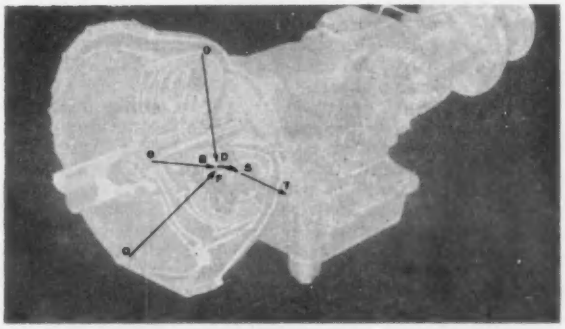
The direction and magnitude of the oil flow leaving any converter member is the same as that entering the adjacent member. Therefore, the vectors, *O-F*, *O-B*, and *O-D*, shown entering the stator are the same as those leaving the second turbine. As the direction of flow changes from *O-F* to *O-B* to *O-D* when the car speed increases, a diminishing torque is imposed on the stator blades. When the oil impinges on the back side of the stator blades, as shown at *D*, the stator free wheels along with the oil so that it will not obstruct the fluid flow.



Second Turbine

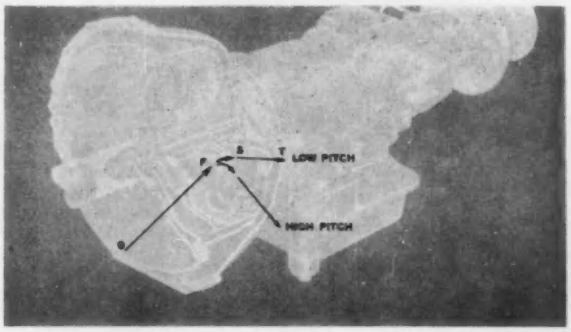
The second turbine has curved blades and has a smaller diameter at its exit end than its entrance end, which further enables it to extract energy from the flowing oil. The exit oil flow is shown by vector sums, *O-A*, *O-B*, *O-C*, and *O-D*.

By virtue of the converter planetary gearset which multiplies the first turbine torque by a ratio of 1.6:1, the speed of this member will be 1.6: 1 faster than that of the second turbine. It is this relationship which enables the first turbine to reduce its load carrying ability while the second turbine increases its load carrying ability. The *difference* in their speeds is zero at stall and increases as the output shaft speed increases. This feature enables the first turbine to move ahead of the second turbine so that the latter can take the driving force of the fluid and deliver it directly to the converter output shaft.



Variable-Pitch Stator, High Pitch

The direction of the oil flow leaving the variable pitch stator will change when the blade is shifted from low to high angle position. The high angle position will result in a greater torque reaction on this member and consequently a higher converter ratio.

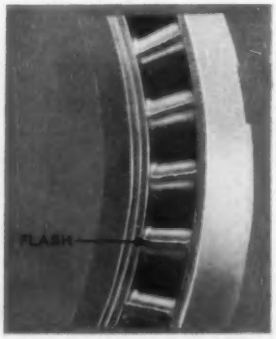


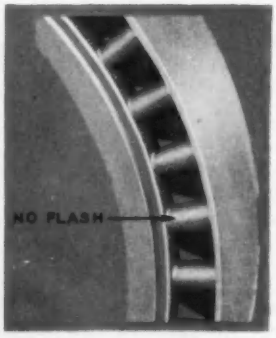
How the 1956 Dynaflow Transmission

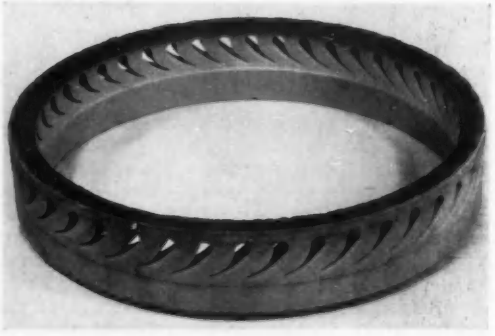
First Turbine

The **first turbine** is a semi-permanent mold aluminum casting. Early 1955 parts were made using individual plaster cores for each opening between the blades. A flash resulted in the casting, where these cores mated together. The flash on this cast element proved to be detrimental to converter performance and no satisfactory way to machine it off was found. Turning the flash off was not too satisfactory, because any reasonable casting and machining tolerances resulted in either some flash remaining, or a flat surface machined on the nose of the blade, which has also proved to be detrimental to converter performance.

This problem of producing **first turbine blades** was solved by the development of a one-piece core. Since there is no parting line between the core sections forming the oil passages, no flash on the rounded entrance end of the blade is encountered. In this manner, a part is now being produced which gives better converter performance and which is more economical to cast.







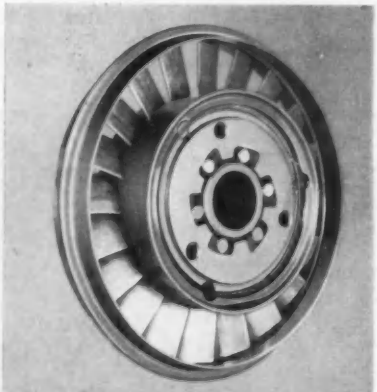
Variable-Pitch Stator

A variety of materials and manufacturing methods is used in making the variable-pitch stator and overrunning clutch assembly. The **stator overrunning clutch** is of the cam and roller design. Accordion-pleated type roller energizing springs are used.

The **rear stator blade carrier** is made of a shell molded iron casting. This part is rough machined.

The **front stator blade carrier** is also made of a shell molded iron casting.

The front and rear carrier halves are bolted and doweled together. This matched assembly is then finished machined, removing 0.015-0.020 in. for finish cuts. The 20 holes for the stator blade cranks are drilled and reamed to a tolerance of 0.002 in. The centerlines of these holes are in the parting line plane of the two carrier sections.



STATOR AND OVER RUNNING CLUTCH

A close hole tolerance is required to minimize oil leakage between the cranks and the crank bearings. The centerline parting permits the usage of a crank and blade sub-assembly, which facilitates the initial assembly and any service disassembly.

The **stator blade crank** is made from close tolerance SAE 1018 drawn wire of 0.1540-0.1550-in. diameter. The offset for the crank is made in a four-slide machine. The serrations which lock the stator blade to the crank are formed by rolling. After rolling this part is heat-treated.

Several types of **variable pitch stator blades**, including sintered powdered iron, die cast, formed sheet steel, and extruded aluminum were considered. They all had their shortcomings in regard to cost, durability, lack of uniformity, or performance characteristics. A smooth surface, a thin trailing end, and practically no variation from part to part were required. A hot aluminum extrusion, cold drawn to maintain uniformity, filled the requirements the best. The cross-section of this cold drawn stock is being maintained within 0.002 in. of the exact contour shown on the drawing. The stator blades are cut from these hot-extruded cold-drawn bars. The ends are broached to form a small thrust area and to give a length of 1.061 ± 0.001-in. The crank hole is drilled and reamed to 0.1557-0.1567-in. diameter.

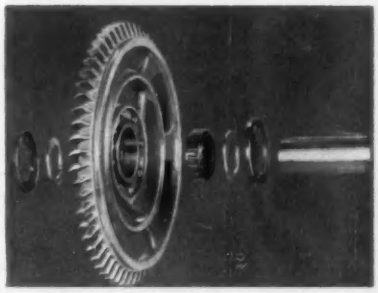
The throw of the crank is positioned in its proper relation to the blade and the crank is pressed into place. The interference fit between the serration on the crank and the hole in the blade locks these two parts together.

The **stator piston or crank actuator** is a sintered powdered iron part. Labyrinth grooves are machined on the inside diameter to provide oil sealing and a groove is turned on outside diameter to accommodate a cast iron oil sealing ring. The weight decrease of this part during machining amounts to only 23%. Most of this material is removed to form the grooves, which cannot be readily cast without encountering back drafts or an extremely complicated die.

The **outer ring or shroud** is a sheet metal stamping. First, a cup is formed from which the draw flange and the bottom are trimmed off, leaving a cylinder of seamless tubing. This cylinder is then placed over a plug and pressed axially between form controlling dies. This causes the center section to bulge out and get squeezed together, thereby forming a very rigid "T" section. The holes which accommodate the outer ends of the crank are pierced in a radial outward direction, so that a smooth surface will be retained on the inside diameter for the stator blade thrust area. No machining is done on this part.

Is Manufactured

Fixed Blade Stator



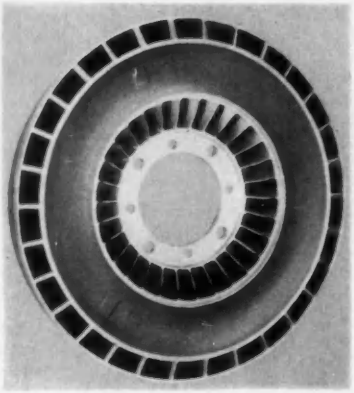
The **fixed-blade stator** is mounted on narrow full floating bearings between which is the **stator overrunnning clutch** (sprag type). This member is a semi-permanent mold aluminum casting. The addition of this element to the 1956 Dynaflow accounts for the improvement in performance.

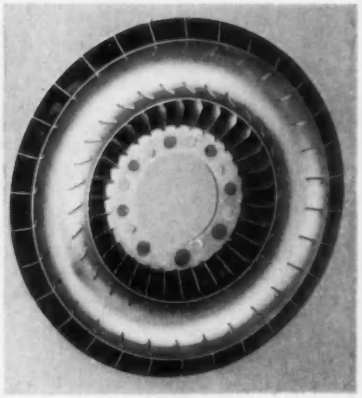
A die cast **stator member** has been produced and is now undergoing durability tests.

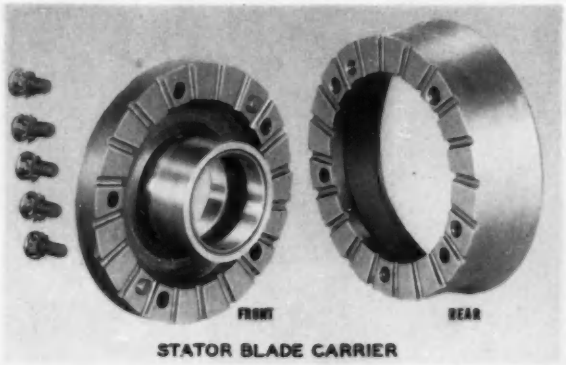
Second Turbine

A semi-permanent mold cast aluminum **second turbine** was used in the 1953-1955 Twin Turbine Dynaflows.

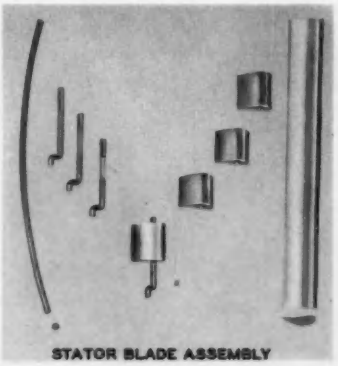
This part is being supplanted by a sheet metal assembly. No performance or weight penalty was encountered in making this change. The thinner sheet steel sections offset the greater specific weight of the material used.





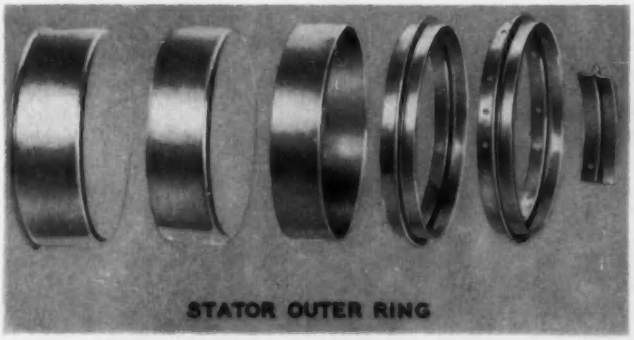


STATOR BLADE CARRIER

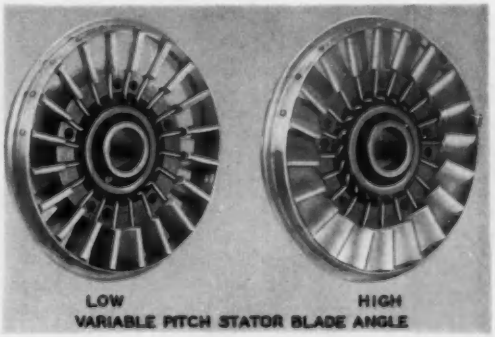


STATOR BLADE ASSEMBLY

STATOR PISTON



STATOR OUTER RING

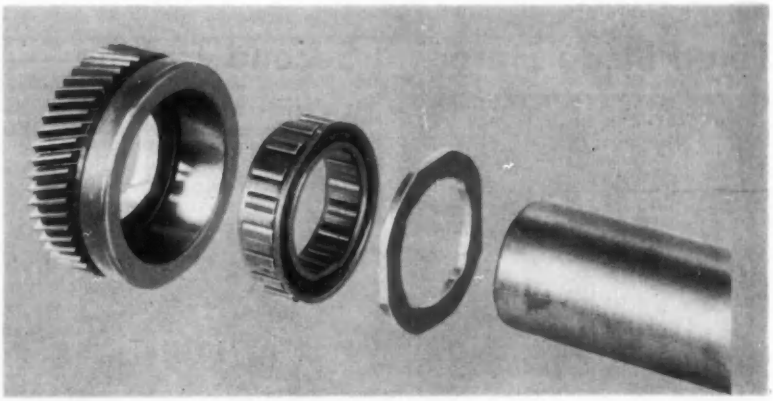


VARIABLE PITCH STATOR BLADE ANGLE

Sun Gear and Overrunning Clutch

A sprag type overrunning clutch is used with the converter planetary sun gear. To maintain concentricity between the outer and inner races, a bearing is pressed into the front end of the sun gear and bored to size, locating from the inside diameter of the sun gear race-way. To the rear is assembled a narrow bronze bearing having very close diametral tolerances and concentricity.

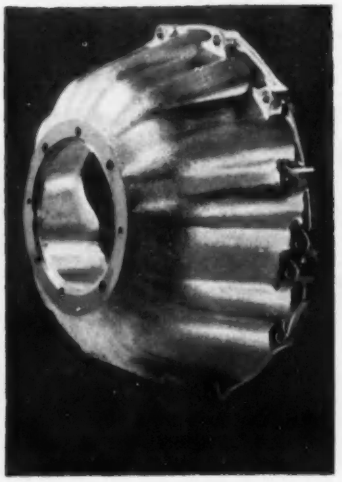
The overrunning unit is a double-cage full-phasing sprag clutch. One of the features of this type of overrunning clutch, in comparison to the cam and roller type, is that it requires less space. With five converter elements, together with a planetary gear set and a variable pitch stator, space limitations have become a very serious problem.



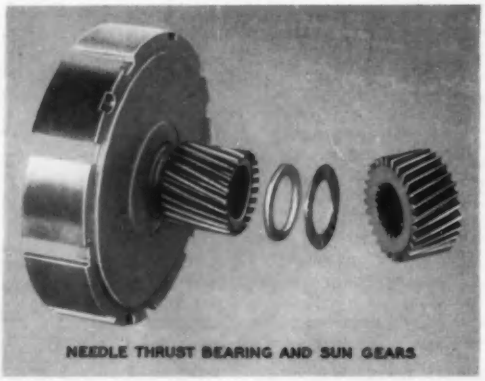
Converter Housing

The 1955 converter housing was a sand cast iron part weighing 24.2 lb. The heavy ribbing used was not for structural purposes, but for acoustic reasons. Before this number of ribs was added, the resonant frequency of the engine and transmission assembly resulted in some objectional noise periods.

A full permanent mold cast aluminum **converter housing** which weighs 7.3 lb is now being used. Instead of ribs, this part has convolutions in the conical wall to provide the most rigidity and strength with a minimum amount of material.



Sun Gears and Thrust Bearing



NEEDLE THRUST BEARING AND SUN GEARS

The plain bronze thrust washer between the sun gears of the transmission planetary gear unit has been replaced by a **needle thrust bearing.** Testing was started on the bearing some time ago. Due to the increase in thrust loads caused by the higher converter torque ratio, a greater capacity bearing was needed. This was accomplished by the needle thrust bearing, in about the same space formerly needed for the plain bronze thrust washer.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

This is the 4th of 7 AUTOMATIC TRANSMISSION ARTICLES appearing in this issue.

Driver can choose two distinct

driving ranges in Studebaker-Packard's

Twin Ultramatic Transmission

C. J. Lucia and J. Z. DeLorean, Studebaker-Packard Corp.

Based on paper "The Twin Ultramatic Transmission" presented at the SAE Golden Anniversary Summer Meeting, Atlantic City, New Jersey, June 16, 1955.

THE Twin Ultramatic transmission, introduced in 1955 Packard, Clipper, Hudson, and Nash automobiles offers two distinct driving ranges to the vehicle operator. The high gear torque converter performance of the original Ultramatic is available at the driver's option. In addition, great acceleration ability can be achieved by coupling the high torque converter multiplication with a low gear ratio of 1.82/1. Thus the redesigned Ultramatic retains the favorable characteristics of its predecessor and adds a new automatic range.

The driver may control the new transmission so that if moderate acceleration is desired the torque converter can be unlocked up to 45 mph by depressing the accelerator pedal slightly. A heavy pressure on the treadle downshifts the transmission to low gear (up to 60 mph) for maximum performance.

The Power Train

Torque converter: The basic components of the power train of the new unit are the same as the old. Most of the numerous design changes were made to lower cost or weight.

As shown in Fig. 1, the torque converter is essentially the same as previous Ultramatics except for a change in the second turbine, which results in a 2.92 stall torque ratio at 1650 rpm with 263 ft-lbs input. A single disc clutch is used to lock the turbine to impeller. It is a two-stage, single-phase, four-element unit, consisting of the impeller, first turbine, second turbine, and the reactor. The outer torus path diameter of this unit is only 10¾ in. Its design allows a greatly extended torque multiplication range over that of other types. It is easily matched to a variety of engine sizes, with stall speed controlled by simply altering the second turbine.

It is the smallest torque converter in the industry and 90 lb lighter than the original Ultramatic. Fig. 2 shows characteristic performance curves, plotted in accordance with latest SAE Hydrodynamic Drive and Transmission Committee Standards. Although the unit is classified as a two-stage converter because of the existence of two turbines, it should be noted that the first and second turbines are fixed to each other and mounted on a common shaft. The second turbine, in addition to controlling stall speed, provides a desirable rising input speed characteristic. If the lock-up clutch is considered as a part of the converter, the efficiency can be stated as being 100%. The one-way clutch is relocated in the hub of the reactor. Although this converter is used with

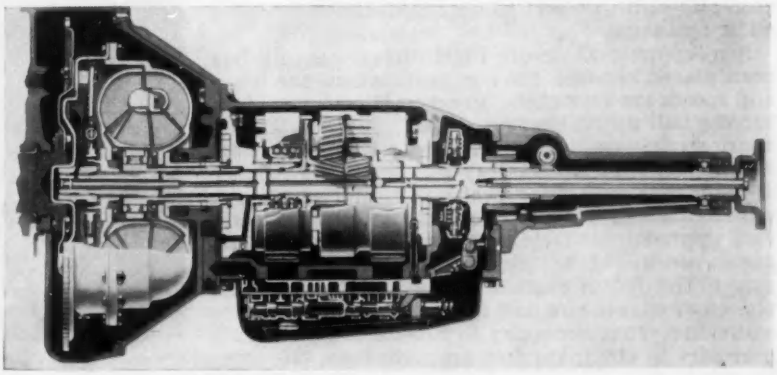


Fig. 1—Twin Ultramatic transmission offers a dual driving range at the operator's option, thus giving a completely automatic system that allows the driver a high degree of control.

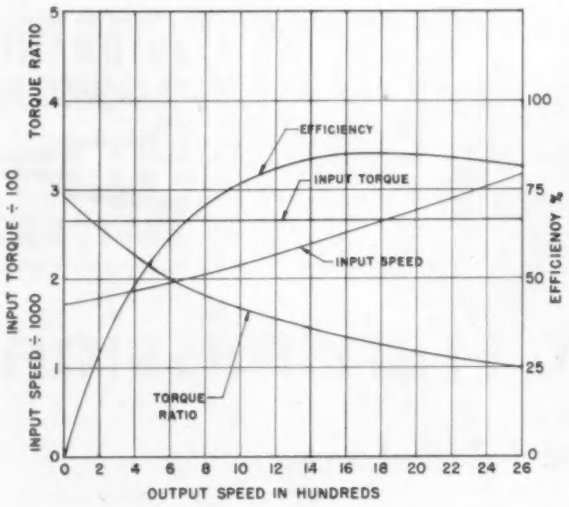

TORQUE RATIO
INPUT TORQUE ÷ 100
INPUT SPEED ÷ 1000
EFFICIENCY %
EFFICIENCY
INPUT TORQUE
INPUT SPEED
TORQUE RATIO
OUTPUT SPEED IN HUNDREDS
0 2 4 6 8 10 12 14 16 18 20 22 24 26
0 1 2 3 4 5
0 25 50 75 100

Fig. 2—Characteristic performance curves of the Twin Ultramatic transmission plotted in accordance with SAE Hydrodynamic Drive and Transmission Committee Standards. Area under the torque ratio curve is greater than any other converter used in passenger cars.

the largest displacement engine used in passenger cars, Studebaker-Packard torque converter engineers have no plans to expand the converter. In fact, to refine this converter design concept, they are more inclined to consider a reduction in diameter.

By casting all four members in aluminum, cavity areas and shape can be controlled, resulting in an inherently quiet unit which is not critical to supercharge pressures. The plaster casting process is attractive when production volume is limited, since tooling costs are relatively low and design changes can be made readily. The cost of fabricating the torque converter by the plaster cast method is high, but we believe that any high performance converter concept can be executed better in cast aluminum. Since the lock-up clutch more than substitutes for high coupling efficiency the design can be refined to provide maximum area under the torque ratio curve.

Gear set: The planetary gear train is the Ravigneaux type. It consists of a driving sun gear, a low range reaction sun gear, and three long and three short pinions, mounted in a shell-molded cast iron cage. The short pinions are deliberately placed "incorrectly" with respect to bearing loading for more quiet operation.

A most unusual needle roller thrust bearing has been placed between the sun gears where the loads and speeds are very high. Previous Ultramatics featured a ball thrust bearing at this location with the bearing races ground integrally with the gears. This design was very satisfactory but costly. This new development in thrust bearings is not only very economical but is remarkably successful in this severe application. Details of the cage construction are shown in Fig. 3. We still silver-solder the gear cage to the output shaft in spite of the fact that the planetary cage is now cast iron, rather than pearlitic malleable. It is necessary to Kolene clean the cast iron part to eliminate free graphite from the joint surface. This construction has proved to be economical and sound. Contrary to custom, there are no spacers used between the two rows of needles in the short pinions.

The new unit makes extensive use of the shell mold process. The parking lock gear is a good example of maximum utilization of this process. This part performs as a coupling between the output shafts, drives the rear pump rotor, and carries the two governor assemblies. Stresses in the parking lock demand the use of pearlitic malleable. The process requires a maximum of control to assure reasonable approximation of gear tooth shape. We retain the parking lock because it is an indispensable safety feature.

The speedometer gear and shaft are integrally molded in nylon, driven by a nylon gear, and mounted in a nylon speedometer gear adapter. The governor assembly is located on the output shaft where it is exposed directly to torsional characteristics of the drive line. This contributes to dependable and accurate governor pressure regulation.

Hydraulic controls: The control problem of adapting the 1.8 gear with locked-up converter to the passenger car is quite complex. Usefulness of the 1.8 gear during the passing cycle depends on two things: maximum useable engine speed and the axle ratio as it affects the over-all engine-to-wheel ratio. The 1.8 gear makes maximum horsepower available at approximately 80 mph, which is the upper end of the 50-to-80-mph passing speed range.

When used with an axle ratio of approximately 3/1, 5.5 over-all ratio is obtained. This provides maximum acceleration performance during the passing cycle. To operate today's passenger car at maximum horsepower in high gear results in car speeds of 120 mph. Obviously if the horsepower rating is to mean anything at all to the motorist it must be in terms of an additional safety factor for the passing cycle. A 4.5 over-all ratio is very attractive as a passing ratio, but the automobile can't be accelerated at a maximum rate in the 50-to-80-mph range.

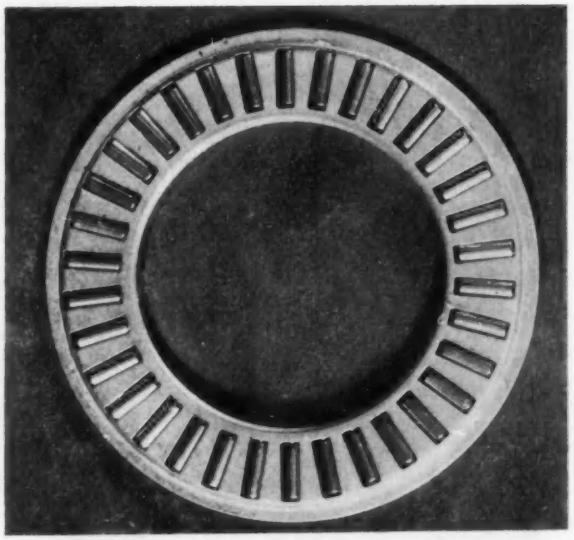


Fig. 3—Cage construction of the Twin Ultramatic transmission.

A 5/1 ratio appears to be a good over-all compromise. This could be achieved by lowering the axle ratio rather than the transmission gearing. The 1.8 gear ratio is nearly ideal for starting, especially if teamed with a high performance converter.

The hydraulic control system shown in Fig. 4 is comprised of front and rear pumps with check valves, a gallery pressure regulator, throttle valve, a governor, and a manually positioned valve. A shift valve for each automatic shift and a regulating type valve for controlling pressures and flow in the converter are necessary. A shuttle type valve is used to direct the activities of the reverse servo since the space for the manual valve is limited.

Servos to actuate the brakebands are quite simple in design. They have no seals on their cylinder caps. The conical shape of the aluminum caps provides near-positive sealing as they expand at the outside diameter when pressure is applied.

The governor is composed of two simple square-of-the-speed regulators connected in tandem to a single circuit. The modulating and throttle limit valves function in combination with the pump valve to provide gallery pressures which not only vary with throttle setting but vary inversely with car speed. This results in transmission capacity being controlled to match the torque to be transmitted.

The pump valve spring force is low but it is assisted by the throttle limit pressure at all times. A gallery pressure, varying between 90 and 170 psi is thereby established. However, the pressure which prevails under specific conditions is determined by the modulating valve, which directs governor pressure to oppose the spring in low range and high clutch pressure in high range. In biasing the spring with clutch pressure we obtain self-compensation against low pressures caused by abnormal leakage. If clutch pressure falls below the control value, the gallery pressure rises to an abnormally high value.

The high clutch pressures are carefully controlled during the low-to-high shift, to provide engagement smoothness, with a higher pressure applied after the shift is complete. This is done by using the low servo as an accumulator, which activates the shift regulator valve. This, in turn, carefully regulates the clutch pressures existing during engagement.

Since the new control system had to be adapted to a unit for which some tools were in existence, compromises were necessary to fit it to the space available and connect to existing oil passages and operating levers. The use of many springs permits excellent flexibility for the designer; however, it introduces tolerances which are undesirable in any system.

For complete paper (in multilith form) on which this abridgment is based write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

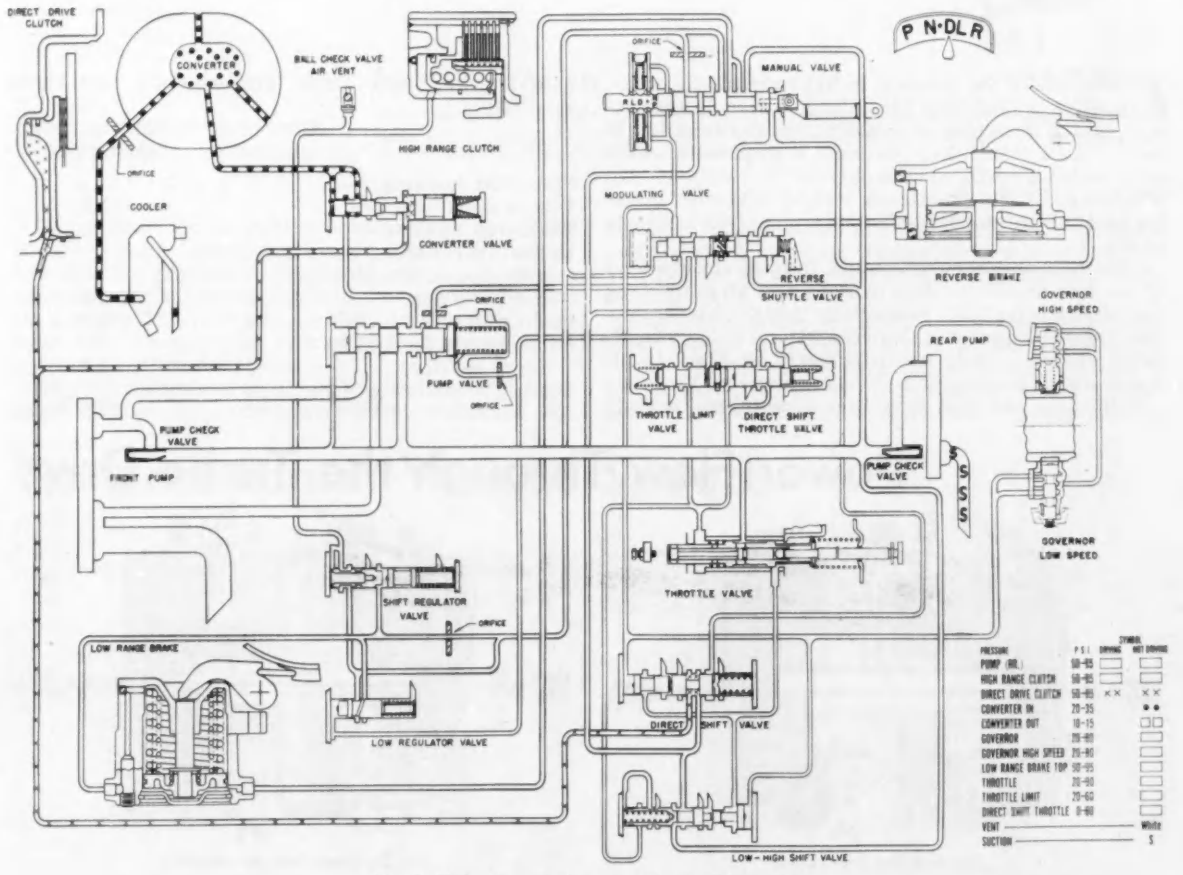


Fig. 4—Hydraulic control system of Twin Ultramatic.

23 Cast Aluminum Parts Keep Weight Low In . . .

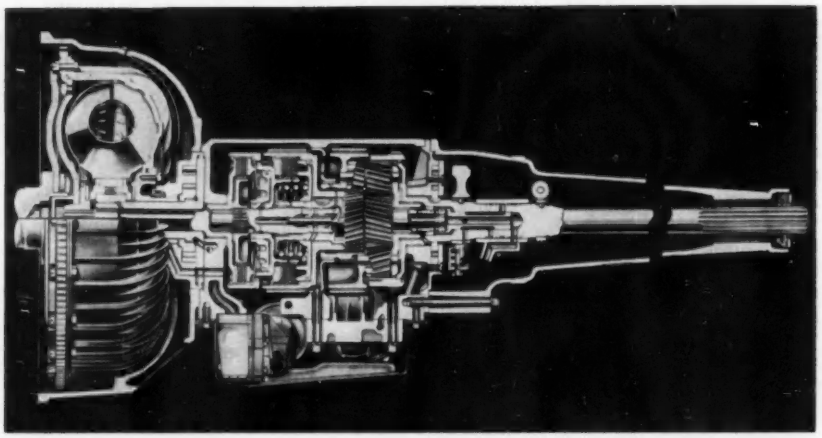


Fig. 1—Lincoln's Turbo Drive Transmission is a three-speed planetary gear type with a single stage hydraulic torque converter. The use of aluminum for 23 parts keeps weight down to 200 lb.

Lincoln's Turbo Drive

AN example of the interest in light metals for automobiles is Lincoln's 1955 Turbo Drive Transmission, which uses precision aluminum castings for 23 parts. As a result, the complete transmission, with all attaching parts, weighs only 210 lb (without oil). A cutaway of the aluminum torque converter housing and the three-speed planetary gear box is shown in Fig. 1.

Although the general design follows closely that of the transmissions used in Ford and Mercury cars, Lincoln's Turbo Drive is specially designed to handle the higher torque of the Lincoln 341-cu in. overhead-valve engine. It is manufactured by Ford in its Automatic Transmission Division plant at Livonia.

Following are the precision aluminum castings used in the Turbo Drive Transmission and their weights:

Part	Number of castings	Weight of rough casting (lb)
Converter housing	1	13
Torque converter	4	11.6
Extension housing	1	6.8
Hydraulic controls, valve body, pressure regulator, and governor	7	4.2
Front and rear servos	6	3.0
Other (clutches and delivery service)	4	1.7
Total	23	40.3 lb

Power Flow Through the Turbo Drive

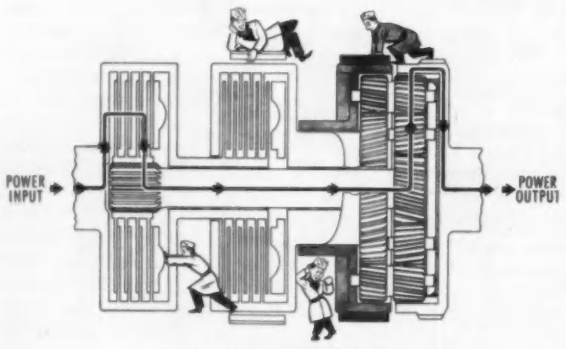


Fig. 4—Power flow—low.

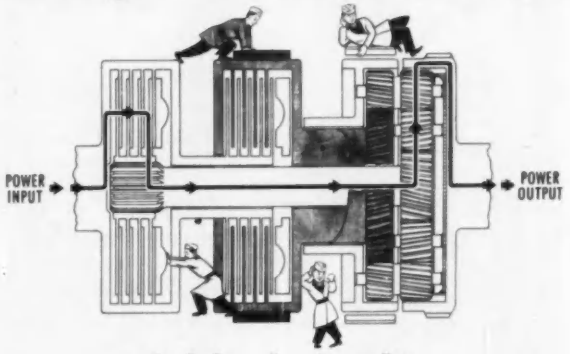


Fig. 5—Power flow—intermediate.

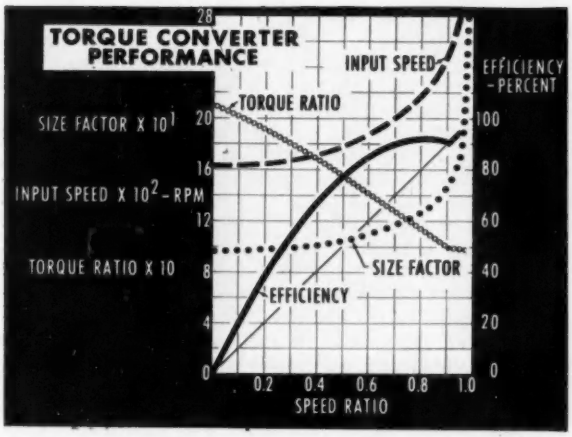


Fig. 2—Torque converter performance. Torque ratio at stall is 2.1, maximum efficiency is 92%, and clutch point is 0.905.

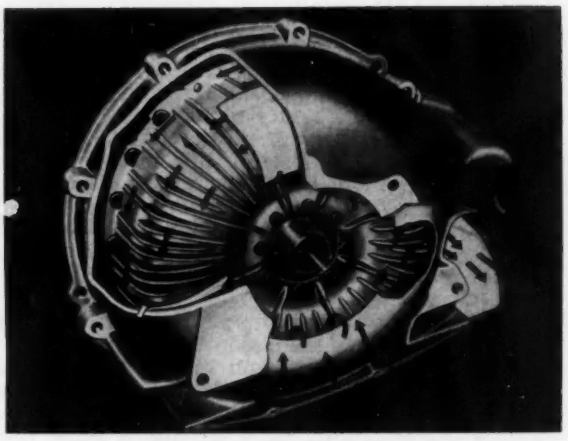


Fig. 3—Vanes on the outside of the die-cast aluminum impeller shell circulate air through the aluminum housing for cooling.

This is the 5th of 7
AUTOMATIC TRANSMISSION
ARTICLES
appearing in this issue.

Transmission

H. G. English, Ford Motor Co.

Based on the paper "Lincoln Turbo Drive Transmission" presented at the SAE Golden Anniversary Summer Meeting, Atlantic City, June 16, 1955.

The aluminum converter housing was developed from a regular permanent mold which ultimately was used for production parts. The first casting was designed for minimum weight and minimum cost by keeping the sections as thin as possible. The mold was subsequently reworked to increase stiffness and reduce deflection.

After the required stiffness was obtained, fatigue tests at five different loads were conducted for 200,000 cycles without failure. During the development of the casting approximately 0.82 lb were added at strategic spots. Final rough weight of the casting was 13 lb.

The torque converter is the single-stage type using three bladed members. Fig. 2 shows performance characteristics of the Lincoln converter in terms of torque ratio, efficiency, and capacity factor plotted against speed ratio of the converter. Torque ratio at

Transmission at Various Speeds

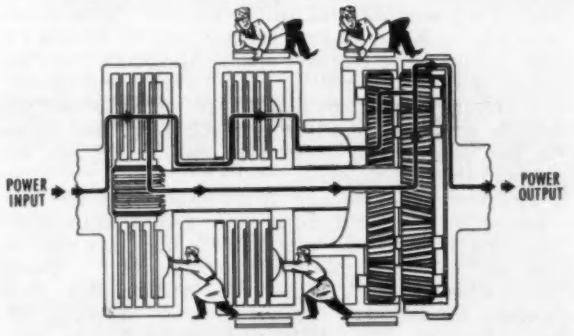


Fig. 6—Power flow—high.

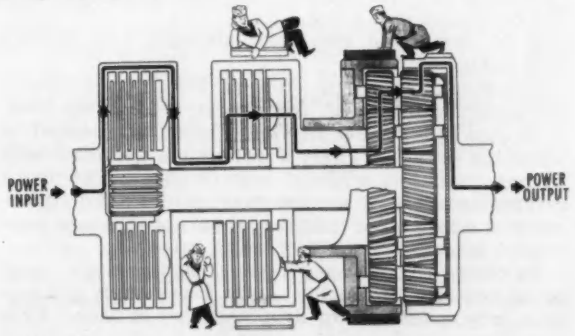


Fig. 7—Power flow—reverse.

stall is 2.1, maximum efficiency is 92%, and clutch point is 0.905.

Diameter of the converter circuit is 12-5/16 in. Both impeller shell and stator are made of die cast aluminum. Impeller blades are made of sheet metal and are held in place by a large snap ring at the outer ends of the blades and the sheet metal core ring. The turbine is made entirely of sheet metal without brazing or welding. Vanes on the outside of the die cast impeller shell circulate air through the converter housing for cooling. No heat exchanger is required. Fig. 3 shows air flow through the converter housing.

The gear set is the double pinion planetary type using two sun gears, six pinion, and one ring gear. Gears are 15.5 in. diameter pitch, 17 deg-30 ft pressure angle and 22 deg-11 ft 30 in. helix angle. Two multiple-disc clutches and two brake bands are used. The front clutch has four pairs of plates and uses semi-metallic friction material. The rear clutch has five pairs of plates and uses sintered bronze friction material. The front band uses a woven asbestos lining with molded end segments and the rear band uses semi-metallic lining.

Power flow through the gear box in low, intermediate, high, and reverse is shown in Figs. 4, 5, 6, and 7.

How It Works

The Lincoln Turbo Drive Transmission provides for full use of geared ratios in a single drive position; however, for smoothness, normal starts are made in intermediate gear. Low gear is brought into action by depressing the accelerator through the detent at speeds below approximately 20 mph. If the detent position is held, calling for maximum acceleration, the transmission will remain in low gear until approximately 35 mph when it shifts automatically to intermediate gear. Normal starting is in intermediate gear and the automatic shift to high gear is accomplished at speeds from 19 to 76 mph, depending on throttle opening. Kickdown to intermediate gear for highway passing can be accomplished at speeds up to 71 mph. Low range position, used primarily for unusually steep grades, provides intermediate gear at any speeds above 24 mph. Below 24 mph with closed throttle the transmission shifts into low gear and remains there regardless of car speed. At full throttle the shift into low gear occurs at approximately 30 mph.

The gear, converter, and over-all ratios are as follows:

	Transmission gear ratio	Converter ratio	Transmission overall	Overall 3.07 axle
Low	2.40	2.1 (stall)	5.04 (stall)	15.47 to 7.37
Intermediate	1.46	2.1 (stall)	3.06 (stall)	9.42 to 4.48
High	1.00	1.54 at 22 mph	1.54 at 22 mph	4.73 to 3.07
Reverse	2.00	2.1 (stall)	4.2 (stall)	12.89 to 6.14

(Paper on which this abridgment is based is available in full from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

All-Wheel Drives . . .

. . . use a transfer case (or drop gear box) to divide the torque and bring the front propeller shaft lower than the engine.

Based on paper by **H. C. McCaslin and G. W. Scharback,** Willys Motors, Inc.

THERE are two major problems to overcome in designing an all-wheel drive:

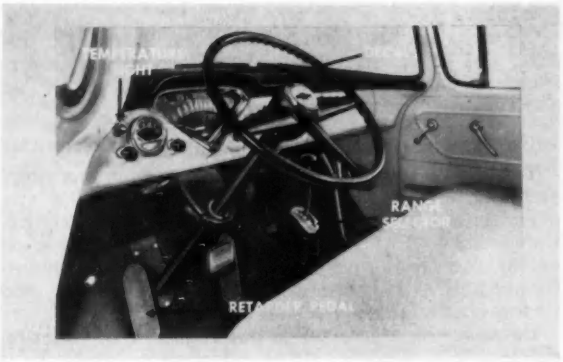
- To divide the engine-produced torque between the front and rear axles.
- To develop a combined steering and driving front axle.

Commonly, the engine is mounted on the frame in its usual manner with the driving end to the rear. It is also mounted somewhat higher than usual to allow the propeller shaft which drives the front axle to pass under it without interference. The front driving axle is very similar to a standard full-floating rear axle except that the wheel spindles are connected pivotally instead of being integral.

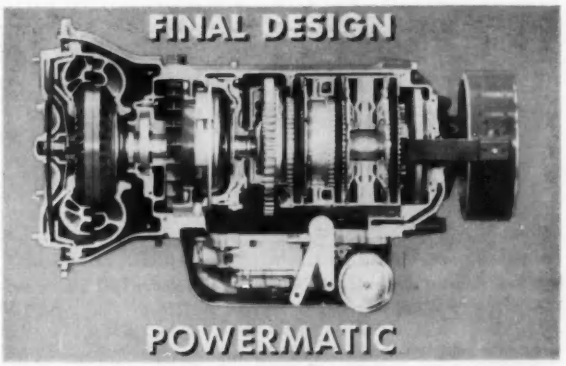
To divide the torque produced by the engine and bring the front propeller shaft lower than the engine, a transfer case or drop gear box is used. This case is usually designed so that the drive to the front axle can be engaged or disengaged with a hand lever, and included in it is a lower gear choice for use where more torque to the wheels at lower vehicle speeds is required.

The design of the transfer case also provides for adding a power take-off unit to its rear. This allows power to be taken off through a clutch unit before it goes through the transfer case. And since the case contains a neutral position for drive to the wheels, the arrangement provides power either when the vehicle is at a standstill or in motion. It also allows for the selection of speed and torque through the gears in the transmission.

The transfer case and front axle make the all-wheel drive vehicle more expensive to produce than the conventional two-wheel drive, but they can do jobs that would be impossible for the latter. (Paper "Multiwheel Drive Vehicles" was presented at SAE Golden Anniversary Transportation Meeting, St. Louis, Oct. 31, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)



CAB CONTROLS consist of the accelerator pedal, the range selector, and the hydraulic retarder pedal. A decal on the instrument panel warns the driver against shifting from Drive to Intermediate above 30 mph and from Intermediate to Low above 15 mph. The tell-tale light indicates when the retarder pedal should be momentarily released to allow the oil to cool.



CHEVROLET'S POWERMATIC transmission includes a torque converter, four planetary gear sets, and a hydraulic retarder. The converter is a four-element, single-stage, three-phase type with two overrunning stators. The first planetary gear set is a splitter gear for the second and third forward sets and the fourth or reverse set. This gives six usable forward speeds.

Chevrolet Introduces in Heavy-Duty Trucks

This is the 6th of 7
AUTOMATIC TRANSMISSION
ARTICLES
appearing in this issue.

THE POWERMATIC

H. O. Flynn, Chevrolet Motor Division, CMC

Excerpts from paper "A New Automatic Transmission for Chevrolet Heavy-Duty Trucks" presented at SAE Annual Meeting, Detroit, Jan. 11, 1956.

THE Powermatic is an all-new automatic transmission developed by Chevrolet in cooperation with Allison for the 1956 Chevrolet medium and heavy-duty trucks.

It was designed to

- give accurate and easy downhill braking control
- simplify maintenance
- eliminate band-type control elements
- eliminate need for adjustments
- include an oil filter
- be easy for the driver to control
- incorporate SAE standard power take-offs on each side

The finished product features completely automatic controls, three specialized drive ranges, and driver overcontrol for unusual driving situations. It's a torque-converter type of transmission with a lock-up clutch. It has three geared ratios plus an underdrive splitter to give six mechanical forward speeds and one reverse. The driver elects the speed ranges. Controls are automatic.

Unlike the other automatic transmissions described in this issue of SAE Journal, the Powermatic incorporates a hydraulic retarder for independent dynamic braking.

The transmission's controls insure that the right ratio automatically goes into action at the right time.

The Three Driving Ranges

With total ratio of up to 7.5-to-1 available for starting, Drive range can be used for practically all driving conditions. The range includes the top four geared ratios plus the converter for starting. All starts in this range are made in third gear (2.691 to 1 ratio) times the converter ratio, which, at stall is 2.8 to 1.

The normal shift schedule is as follows: The lock-up clutch engages at 2000–2600 engine rpm, depending upon throttle opening. From third gear the shift to fourth is made between 2600 and 3800 engine rpm, depending upon throttle opening. With light throttle settings the next shift is from fourth to sixth. At wide-open throttle the shift is from fourth to fifth, and then to sixth, both shifts coming at 3800 engine rpm.

At 12–30 mph in sixth gear a slight throttle pressure will force a sixth to fifth downshift. Forcing the throttle to detent will give a sixth to fourth downshift. Forcing the throttle through the detent will give a sixth to third or fourth downshift for maximum performance depending upon vehicle speed.

At road speeds of 30–50 mph in sixth gear, forcing

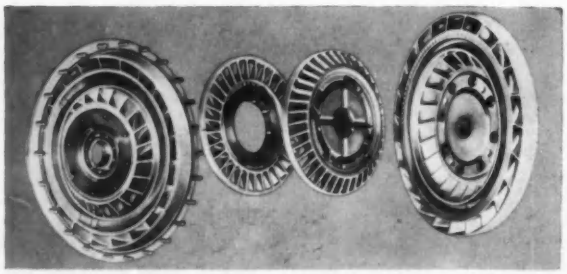


Fig. 1—Converter elements are (left to right) turbine, first stator, second stator, and pump.

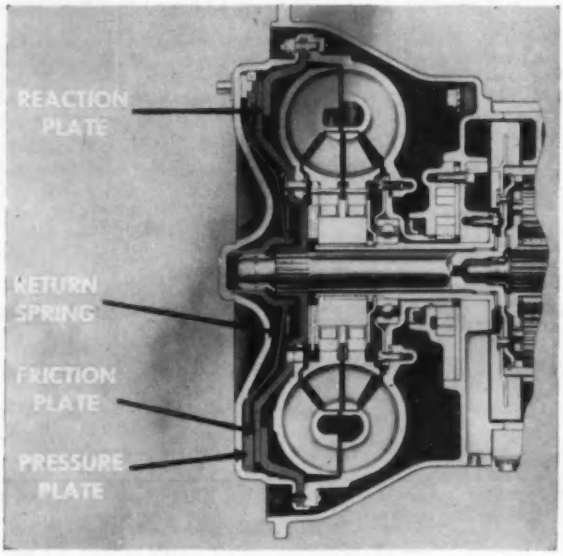


Fig. 2—Lock-up clutch

the throttle through detent will give a sixth to fifth downshift.

All wide-open throttle up-shifts in drive range are made at 3800 engine rpm. Downshifts occur at 2400 engine rpm.

Low range, which includes converter and first, first, and second gear, is a very specialized range used for maximum tractive effort in moving heavy loads of extreme grades, maneuvering at low vehicle speed where rolling resistance is great, and other like situations where the utmost tractive effort is required.

The normal operation includes: all starts in first gear and converter with the converter lock-up clutch engaging between 1800 and 2400 engine rpm, depending upon throttle opening. The shift from first gear to second gear occurs between 2600 and 3800 engine rpm, again depending upon throttle opening.

Intermediate range restricts operation to converter and third, third gear, and fourth gear. All starts are made in converter as in Drive range.

This range is most important for use where additional control of the vehicle is desired at low speeds by permitting higher engine speeds for accelerating or decelerating. This range is very useful in driving in heavy traffic with a heavily loaded rig. It is also very effective in combination with the hydraulic retarder.

There is no provision to allow an automatic upshift out of Intermediate under any engine overspeed situation. As such it gives the driver an absolute over-control of upshifting.

Transmission Components

The **converter,** an all-aluminum casting, is a four-element, single-stage, three-phase type with two overrunning stators (Fig. 1). Torque multiplication is 2.8 to 1 at stall. The seal between the converter and front pump is a Teflon material, chosen for its ability to withstand high temperatures, and its low coefficient of friction.

Because the converter is not required to function efficiently as a direct drive coupling, a large share of the usual compromise in blade design is avoided.

The design freedom resulting from the lock-up arrangement permits blade configuration that will give a relatively high multiplication factor with efficiency, during the multiplication stage, comparable to that ordinarily attained in considerably milder converters. Lock-up ordinarily occurs just past the fluid-coupling point. When conditions favor delaying the lock-up, such as when maximum performance is desired, the driver may do so by forcing the accelerator through the detent position.

So that the best possible fuel economy would be realized over the most used driving range, a hydraulically actuated lockup clutch (Fig. 2) is arranged in parallel with the converter. The hub of the driven plate is splined to the transmission input shaft and carries the converter turbine. The nonmetallic friction faces are molded into a single biscuit with internal driving teeth. The reaction plate is carried by the bolts connecting the converter cover to the converter pump housing assembly, and the pressure plate is driven with the converter cover through dowels.

The pressure plate is a shrink fit on its own diaphragm return spring. These two pieces constitute the clutch apply piston. A ring on the pressure plate seals the outside diameter, and the spring forms its own seal against a ring on the hub of the cover assembly. Positive control of the clutch is provided by the following pressure schedule:

When operating in converter, charging pressure is maintained at a sufficiently high level to eliminate cavitation and to provide a circulation rate through the converter that will satisfy the oil temperature requirement. This charging pressure plus the spring force holds the clutch out of engagement during this phase.

Concurrent with the lock-up engagement, charging pressure is lowered, and the apply pressure is directed to the forward side of the pressure plate. The raising and lowering of converter charging pressure, alternately with lock-up clutch apply pressure, assures positive and accurate control of this clutch under all conditions.

Essentially, the retarder (Fig. 3) is a double-circuit fluid coupling with the "output" element grounded. Thus we have the effect of a fluid coupling operating at stall. The impeller is attached to the ring gear of the splitter set. The grounded element is cast as part of the case in the rear and part of the converter bell housing at the front. This vaned cavity in the case is open to the retarder control valve at the lower right hand side.

A foot-operated pedal to the left of the steering column controls movement of the retarder control valve through direct linkage (Fig. 4). When the pedal is operated, an exhaust port is immediately blocked and oil from the pumps allowed to pass through the control valve to the cavity. The oil circulates through the cavity, absorbs energy in the form of heat, passes back through the retarder control valve body at a controlled rate, and then is directed to an external oil cooler. The valve is shown in a partially applied position.

Oil from the retarder is sent to the main regulator valve to increase the holding force of the clutches to meet the increased need.

When the pedal is released, the control valve returns to its closed position, the main oil supply is cut off, and the centrifugal pump effect of the impeller forces the remaining oil out of the cavity into the sump.

The "feel" of the retarder differs from conventional brake pedal operation because the filling of the cavity is not instantaneous.

After becoming accustomed to the approximately 1-sec fill time, the driver soon knows what to expect and uses the control accordingly. The gradual fill eliminates the possibility of putting severe shock loads on the drive line and axle during application.

The retarder gives three ranges of retarding which, at higher engine speed, is in the region of 300 to 400 hp. The exponential relationship of the horsepower-speed curve gives very effective retarding down grades and in situations where it is necessary to use the retarder constantly. However, experience has shown that there are very few grade situations where the retarder is required for prolonged periods.

Chevrolet engineers feel certain that the operational value of this new transmission is enhanced considerably because of the incorporation of the hydraulic retarder. They found it doubled brake life in their installations.

A plate-type heat exchanger is located in the bottom tank of the engine radiator and utilizes the engine cooling system to maintain satisfactory oil temperatures. Tests have shown that the requirements for the engine cooling system were very nearly the same, ascending the grade at full throttle, or descending using the hydraulic retarder.

The governors used in Powermatic employ the familiar pitot tube in a new role. The front governor, by translating turbine shaft speed in terms of oil pressure, determines the lock-up point and influences the first-to-second shift point. All subsequent shifts are influenced by the rear governor, which senses output shaft speed.

The pitot tubes (Fig. 5) measure fluid flow.

In each governor, a vaned oil collector ring is attached to a rotating member whose speed may then be measured hydraulically. No amplification is needed. The oil entering the tube acts directly on the control valves involved.

As the oil collector ring rotates, the vanes cause the oil to rotate with it. Since the pitot tube is stationary, the velocity of the oil at the point of contact with the tube is reduced to zero. This causes a pressure which can be readily calculated. In addition to the velocity pressure, the tube also measures the centrifugal pressure caused by the weight of the rotating ring of oil. This pressure is also calculable.

The tube measures the sum of these two pressures, both of which vary with the square of the speed of rotation.

Accuracy depends first upon keeping the oil level constant. A bleed hole from the oil pumps feeds an adequate oil supply to keep the collector ring full,

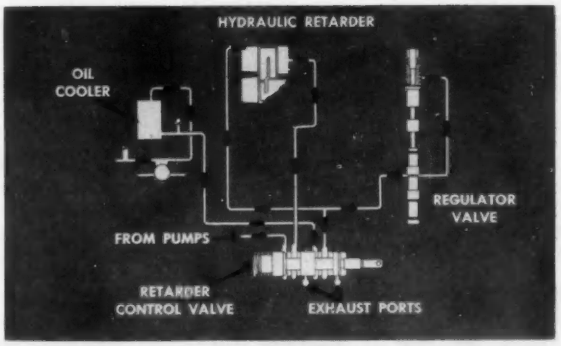


Fig. 4—Hydraulic retarder control circuit

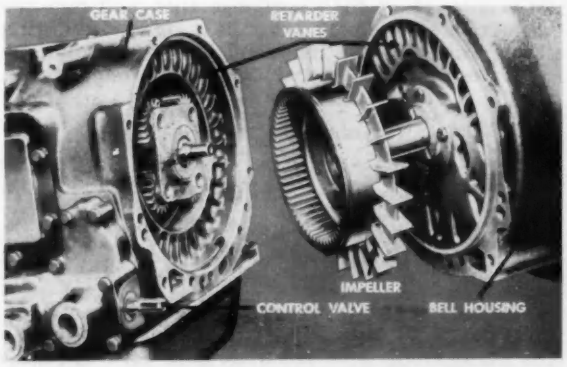


Fig. 3—Hydraulic retarder components

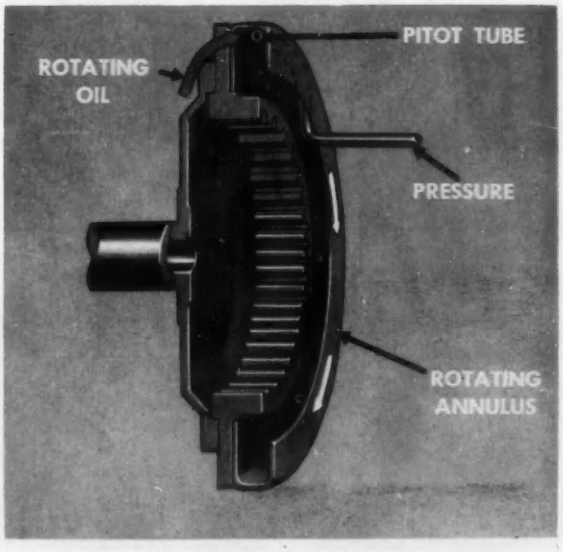


Fig. 5—Pitot velocity head governor

and the open inside diameter of the ring limits the top level which the oil can reach.

Gear Train

The gear train (Fig. 6) consists of four simple, rugged, spur gear planetary sets. A series arrangement of the planetaries allows the first set to become a "splitter" for the second and third forward sets and the fourth or reverse set. Employing the splitter principle makes it possible to provide six usable forward geared speeds following a geometric pattern of approximately 39% steps.

The splitter gear is 1.39/1 in reduction and is used in combination with the 3.81/1 low gear set to produce a 5.29/1 reduction in first gear and with the 1.94/1 intermediate set to make a 2.69/1 third gear. The splitter alone in reduction is the fifth gear. To complete the six-speed pattern, the splitter is locked in direct and the basic low and intermediate gear sets provide the second and fourth gears as shown in the table below:

Gear	In Reduction	Ratio
1st	Splitter and Low	5.294/1
2nd	Low only	3.810/1
3rd	Splitter and Intermediate	2.691/1
4th	Intermediate only	1.936/1
5th	Splitter only	1.390/1
6th	None	1.000/1
Reverse	Splitter and Reverse	6.042/1

Clutches

So that side thrusts on the shafts, gears, and housing would not be introduced into an otherwise co-axial design, the use of bands, with their attendant linkages, anchors, and servos, was dismissed in early considerations. The decision to go to an all-clutch design proved twice-blessed when the hydraulic retarder entered the picture. Because clutches have equal holding capacity in either direction, the retarder brought no new clutching problems. Consequently all clutches are plate type, either single or multiplate, and are either "direct acting" or "polar lever" applied.

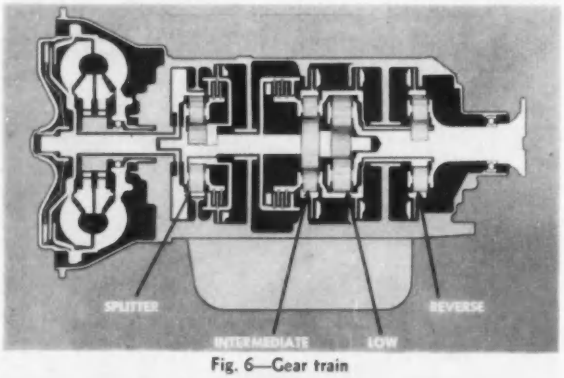


Fig. 6—Gear train

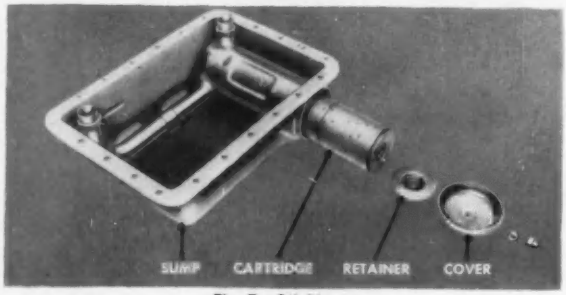


Fig. 7—Oil filter

The direct acting clutches include the lock-up, splitter high, splitter low, and high clutches, all of which carry much lower maximum torque load than is required of the "polar lever" applied clutches.

Of the four directly applied clutches, three distinctly different types of clutch plate material are used:

1. The lock-up clutch which must absorb full engine torque, is a rigidly molded, single plate biscuit incorporating a synthetic rubber augmenting agent.
2. The splitter-low clutch is a fully metallic single plate with sintered facings and steel core.
3. The splitter-high and high-gear clutches are constructed of newly developed steel-backed, non-metallic plates.

The four "direct acting" clutches differ in construction details as well as material. Each is designed to meet the specific requirements placed upon it. The "splitter" clutches, for instance, must absorb only about 39% of the turbine shaft torque, while the high-gear clutch must absorb up to 1.025 times turbine torque. However, the splitter clutch plates must have adequate holding capacity and low peak torque characteristics for smooth shifts. The splitter clutches must also have a high coefficient of heat transfer to withstand the repetitive application cycle with little time interval for cooling.

To meet these requirements, the fully metallic single plate was chosen for the splitter-low clutch where the slip speeds are highest and heat conduction area the greatest. This single plate, having a mean radius of 4.6 in. and area of about 20 sq in. has better "working conditions" than its companion clutch, the splitter-high.

The splitter-high clutch uses two non-metallic steel backed plates with a mean radius of only 3.5 in. and an area of 18 sq in. to cope with a slightly lower slip speed of about 0.72 times turbine shaft speed. Heat conduction conditions are less favorable by virtue of its location.

The high-gear clutch employs three non-metallic plates because it must handle high torque loads with less slip speed on engagement than the splitter clutches.

In all clutch construction considerations, judicious use was made of the knowledge that well directed lubrication can help dissipate heat generated during clutch engagements since oil has approximately five times more heat capacity than the metal parts.

Other Components

The 9½-in. diameter by 3-in. external contracting parking brake is operated by direct linkage from a hand lever on the cab floor.

The full flow oil filtering system (Fig. 7) has a replaceable cartridge located in the sump pan. It is accessible simply by removing one nut on the oil pan cover. The filtering medium is orlon.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

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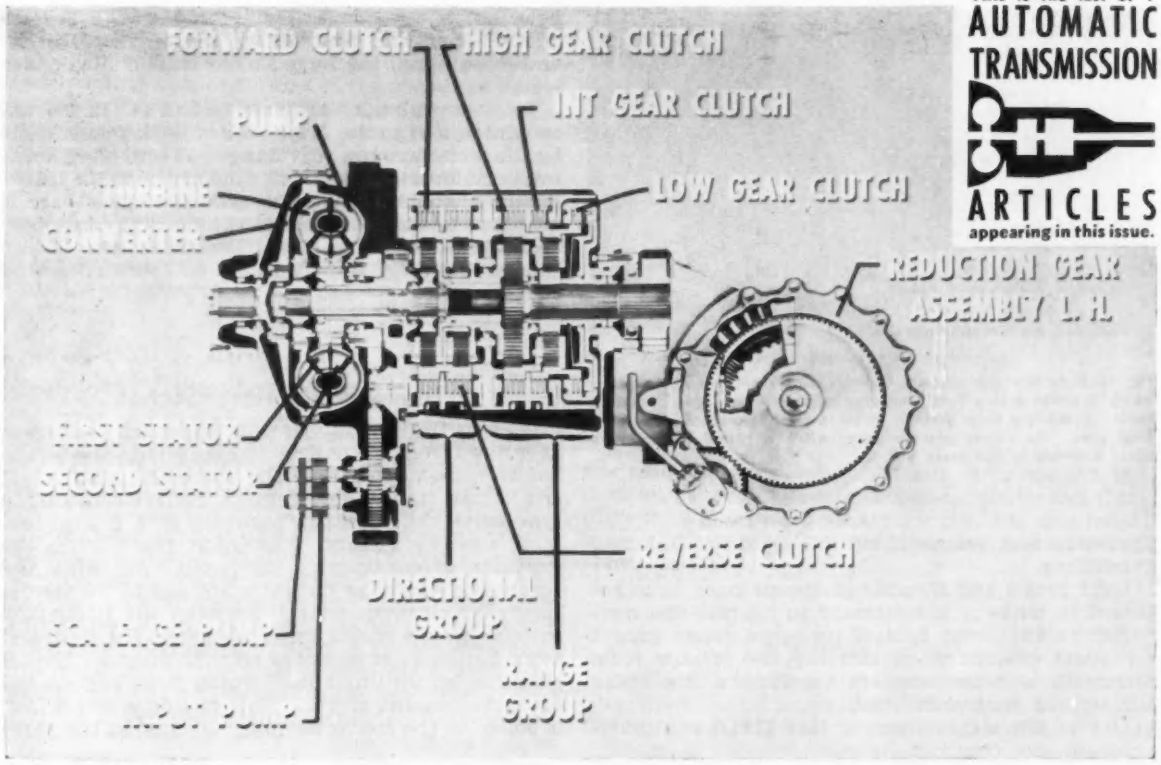

THE HEART of the Euclid twin diesel crawler tractor is a single-stage, multiple-phase converter coupling combination, plus a constant mesh planetary gear unit with hydraulically operated multiple plate clutches, plus a reduction gear assembly joined together to form one compact unit . . .

The Allison TC-12 Torqmatic Transmission

R. C. Williams,
Euclid Division, GMC

H. C. Kirtland,
Allison Division, GMC

C. M. Jordan,
Styling Section, GMC

THE ALLISON Torqmatic Drive—which was designed for the TC-12 twin-engine crawler tractor —incorporates some of the most advanced developments in automatic quick-shift power transmission for heavy earth-moving equipment. Using the torque converter as the nucleus of the drive, a constant mesh planetary gear train with hydraulically controlled multiple plate clutches was added to the infinitely variable torque ratio of the converter. This combination results in extreme smoothness, flexibility, and ease of controlling the twin-crawler tractor and the elimination of the need for clutch

BASED ON THE PAPERS "Twin Power for Easy Mobility," "Torqmatic Drive, Its Part in Easy Mobility," and "The Twin Crawler Takes Shape," presented at the SAE Golden Anniversary Tractor Meeting, Milwaukee, Sept. 13, 1955.

THESE PAPERS are available, as one preprint, from SAE Special Publications Department. Price: 35¢ each preprint to SAE members; 60¢ each preprint to nonmembers.

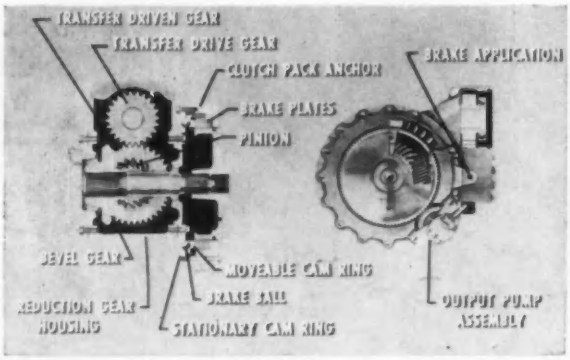

Fig. 1—Reduction gear assembly consists of a gear train and a pinion which is mated with a bevel ring gear splined to the reduction output shaft. A multiple plate brake is mounted on the outboard side of the final drive. An output pressure pump which is bolted to the brake cover is driven by the brake hub.

operation and gear shifting during most operating conditions.

Gear ratios and number of speeds have been selected to make it unnecessary to operate the converter in the lower half of its speed range except for short periods when starting the tractor from standstill or when accelerating from a low speed under light load conditions.

One of the big features of this Torqmatic Drive, however, is the "sense-feel" forward and reverse control operation that allows the operator to literally "squeeze" the huge Euclid tractor into heavy loads.

Two transmissions are used in the TC-12 tractor, each mounted to the drive case of each main frame by the planetary box rear flange. A converter housing is mounted to the front face of the main transmission housing, while the reduction gear case is mounted to the rear face of the housing and operates inside the drive case. The drive case is also the reservoir for the transmission lubricating and operating oil.

Torqmatic Converter Section

Back of the engine this unit harnesses the power as it flows from the engine and multiplies the torque before transmitting it to the planetary gearing. It is a single stage, four element, converter-coupling type drive that consists basically of a pump, turbine, and two stators. The input shaft drives the converter pump through the pump cover while the turbine or converter output is splined to the planetary gearing input shaft. Between the pump and turbine on the inside torus diameter, the first and second stators are mounted on overrunning clutches that run on an inner race which is splined to the converter ground sleeve. This ground sleeve which is bolted to the converter housing supplies the reac-

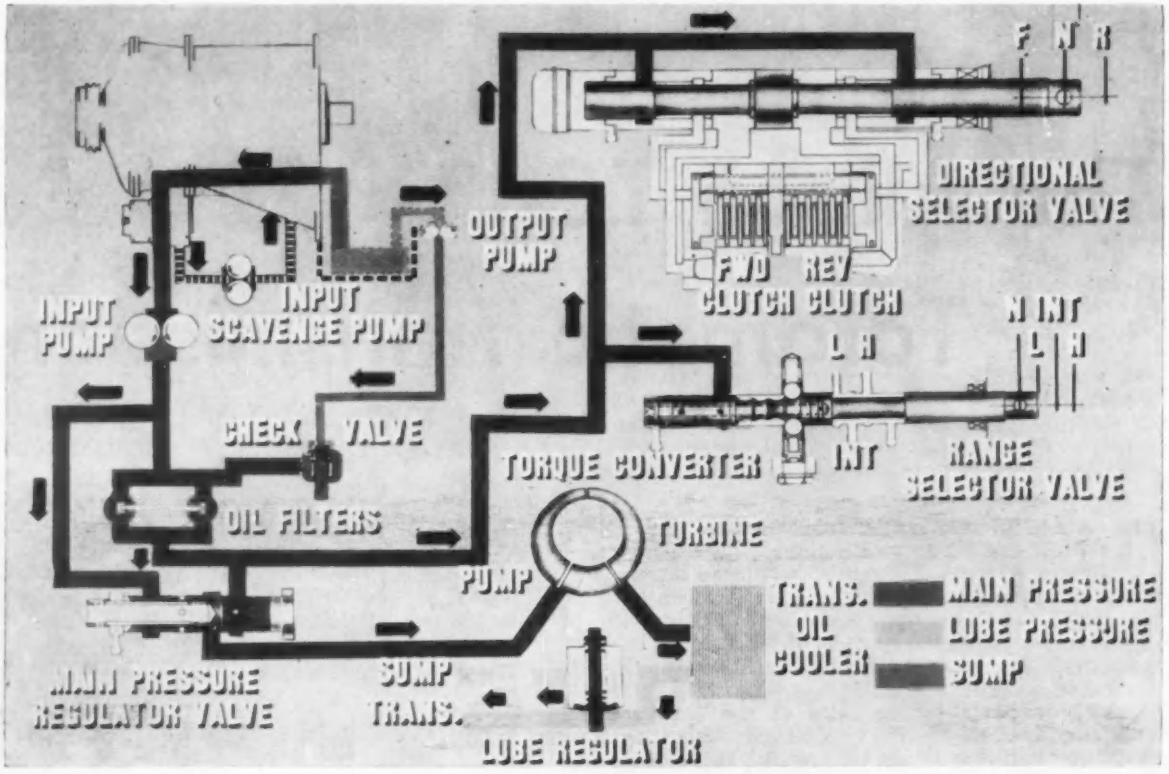

Fig. 2—Schematic of Torqmatic Drive hydraulic system

tion for the stators when the converter is multiplying torque.

A combined scavenging and input pump is mounted in the lower portion of the converter housing and is driven by the converter pump through a suitable gear train. The input pump takes oil from the transmission oil reservoir (drive case) and delivers it under pressure to the converter, the forward and reverse selector valve, and the range selector valve through the main pressure regulator valve. The scavenge pump removes oil leakage from the converter housing and returns it to the transmission reservoir.

Planetary Gearing

To meet the ever-changing operating conditions while the tractor is working, a constant mesh, planetary gear train, controlled by hydraulically operated multiple plate clutches, is used to give the driver a selection of gear ratios or speeds.

These ratios are provided by four simple planetary systems which may be divided into two groups—the directional group (forward and reverse systems), and the range group (low, intermediate, and high range). Two simple planetaries are combined to form the directional group. One provides forward operation to the tractor final drive while the other gives reverse direction to the same drive.

For the range group, also, two planetaries are used to provide the driver with a choice of three speeds —low, intermediate and high. By using a combination of these two groups of the gear train, the operator can select one of three forward speeds or one of three reverse speeds.

To control the combination, a dual selection valve is mounted on the main transmission housing. This dual control consists of a forward and reverse selector valve and a range selector valve. Movement of the forward or reverse selector valve directs oil under pressure from the input pump to the forward or reverse clutch depending upon which direction has been selected for the operation.

However, for range selection, the operator shifts the range selector valve into either low, intermediate, or high. With the movement of this valve into one of the three speeds, oil under pressure is directed to the proper clutch.

In order for the transmission to transmit power to the tractor final drive, both valves must be placed in the selected operating position suitable for the working conditions under which the tractor is expected to perform. On twin engine tractors, the range selection of both transmissions is controlled through one shift lever connected to the range selector valve of each transmission. However, the forward and reverse selector valves are controlled individually, making it possible to control the drive to each track. This feature provides the ability to make full pivot turns.

Reduction Gear Assembly

The reduction gear assembly performs three functions: it changes the direction of power flow from the transmission output shaft through 90 deg to the tractor final drive quill shaft, it provides a reduction between the transmission output and final drive, and it provides brakes for steering and parking. A diagram of the reduction gear assembly is shown in Fig. 1.

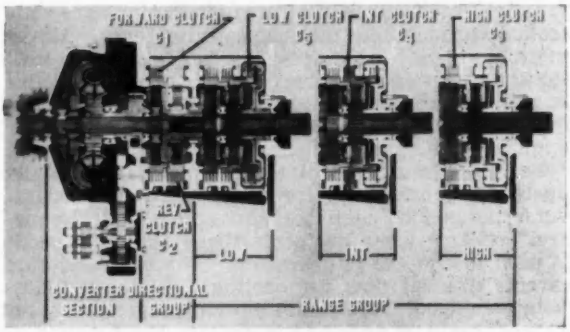

Fig. 3—Torqmatic Drive power flow.

Hydraulic System

In the TC-12 Torqmatic Transmission, oil pressure is employed to maintain charging pressure in the torque converter, operate the multiple plate clutches in the transmission, lubricate the moving parts and circulate oil through the converter-heat exchanger. Fig. 2 is a schematic of the hydraulic system.

Oil pressure is produced and maintained under all operating conditions by two oil pumps. The input pump which is mounted on the front of the transmission operates whenever the engine is running and delivers pressure to the control system and converter.

The output pump is located on the reduction gear housing and is driven by the brake hub which is splined to the output shaft. This pump is in operation only when the vehicle is in motion.

In normal operation the input pump draws oil from the sump and filters it before delivery to the directional and range control valves. With the clutch lines to the control valves filled, the oil cascades through the main pressure regulator valve into the converter where it furnishes charging pressure and carries away heat for the converter.

After the oil passes through the converter it is directed to the oil cooler, back to the transmission lubrication system, and finally to the oil reservoir.

Shifting and Directional Control

All clutches are engaged by oil pressure and released by spring pressure. The hydraulic pistons normally operate as follows: oil pressure acting on the piston overrules the spring pressure and engages the clutches with sufficient unit pressure to provide the necessary reaction torque. Releasing of the clutches is accomplished by exhausting all the oil pressure from the pistons.

As mentioned before, on twin engine tractors, the

range selector valves of both transmissions are controlled through one manual selector lever. Movement of this lever changes simultaneously the position of both selector valves in their respective valve bodies. These valves open or close ports, as required, to direct the oil to the proper passages for engaging the range clutches.

For directional control, there are two individually operated clutch levers for shifting the forward-reverse portion of each transmission. Each "sense-feel" control lever performs three functions as it is used in the TC-12 operation. The initial motion directs line oil flow for cooling the clutch plates being engaged. Additional motion progressively restricts this flow and directs oil into the forward or reverse clutch piston cavity, causing a pressure rise on the apply piston as well as on the differential feel area of the control valve, so the operator feels the pressure in direct proportion to the clutch capacity. The final motion cuts off the clutch cooling flow and also oil pressure to the feel area giving an over-center effect to the full-on position, at which time full main pressure is applied to the clutch. The lever will then remain in the "engaged position" until it is released by the operator.

This control makes it easy for the operator to do more work with less effort and at the same time it permits him to literally squeeze the tractor in either direction without danger of overheating the forward and reverse clutch plates.

Power Flow

With both the directional and range selector valves in neutral, oil pressure is shut off from all hydraulically operated pistons and all multiple plate clutches are disengaged. Both input and output shafts are free of each other and no power is transmitted through the planetary gears.

In all direction or range operations the engine torque enters the torque converter where it is hydraulically multiplied or transmitted automatically to the various gear combinations selected.

Forward—Low Range

For forward low range operation the range selector valve is moved to low position applying hydraulic pressure to clutch C_3 which locks the planetary range group together providing 1/1 torque ratio. (See Fig. 3). The forward clutch C_1 is engaged by moving the directional control lever to the forward position providing a 3.04/1 torque ratio which is combined with the low range torque ratio of 1/1. This combination furnishes an overall reduction of 3.04/1 from the directional group to the reduction gearing.

Forward—Intermediate Range

With the forward clutch C_1 still engaged, intermediate gear operation is obtained by moving the range selector valve to intermediate position. This applies hydraulic pressure to clutch C_4, which produces a compound action of the two simple planetary gear sets of the range group resulting in 0.496/1 overdrive ratio. Combining this ratio with the forward directional ratio of 3.04/1, the overall reduction through the transmission gear train becomes (3.04×0.496) 1.51/1.

Forward—High Range

This combination is obtained by continuing the engagement of the forward directional clutch C_1 and moving the range selector valve to the high range position directing oil pressure to the C_2 clutch. With this clutch engaged, the high range ratio becomes 0.250/1 which, combined with forward directional ratio of 3.04/1, produces an overall gear train ratio of (3.04×0.250) 0.76/1.

Specifications of Allison Torqmatic Transmission

Length	56⅞ in.
Width	27⅞ in.
Height	31¼ in.
Weight (dry)	2320 lb
Oil capacity	35 gal
Reduction gear ratio	2.25/1
Maximum converter multiplication	3.10

Gear ratio	Forward	Reverse
low	3.04	3.17
intermediate	1.51	1.57
high	0.76	0.79

Reverse Operation

Reverse direction can be obtained with all gear ranges described above by moving the directional selector valve to the reverse position which applies oil pressure to clutch C_2 of the directional group. The ratio in this position is 3.17/1 which is practically the same ratio as in forward direction gear. In reverse operation this ratio is combined with the low (1.00/1), intermediate (0.496/1), and high (0.250/1) range ratios in the same manner that they were combined with forward directional operation.

For normal operation, the operator selects the range which suits load demand requirements and then merely moves the forward and reverse selector valve back and forth to maneuver the tractor through its working cycle. Of course, additional maneuverability can be obtained by using the dual engine throttle and brake arrangement for controlling each track.

Euclid's TC-12 Twin Crawler Tractor . . .

. . . was designed to fill the need for more horsepower and greater pushability on modern earthmoving jobs.

Based on paper by **R. C. Williams,** Euclid Division, CMC

THE TC-12 tractor by Euclid is made of two tractor chassis which are hinge-mounted at approximately the center of gravity of each of the halves on a large cross shaft. Each tractor half contains a main frame, a gear box which houses the bevel gearing, and mounts the Allison Torqmatic transmission. It also mounts the drop gearing and final drive gearing for driving the sprocket and the roller frame and track system.

The engine for each half is a Detroit Diesel 671 engine directly connected to a drive shaft into the torque converter, which is mounted on the transmission. The transmission controls the flow of power to the sprocket. The final reduction is the large heavy-duty Euclid planetary reduction used on the large Euclid trucks. (See Fig. 1). The power from the sprocket is transmitted to the crawler track in the conventional manner.

The Euclid design departs from the conventional in several ways. The radiator, shown in Fig. 2, is mounted to the rear of the driver instead of in front of the engine. This places it in the least vulnerable spot on the tractor. Any dirt falling off the bulldozer does not get blown at the operator. Too, the fan blast to the rear blows away the dirt that tends to rise up behind the operator.

As the tractor goes over rough ground the two tractor halves are permitted to rock with respect to each other. In the Euclid design the roller frames and chassis are essentially one piece. Each main frame has welded to it a large steel casting called a pivot housing. Into one of the pivot housings, shown in Fig. 3, a 7-in. shaft is pressed in on a taper. This locks the pivot shaft into the housing. The other housing carries two plastic bearings which form the oscillating bearings for the two halves of the tractor.

The power train arrangement on the TC-12 per-

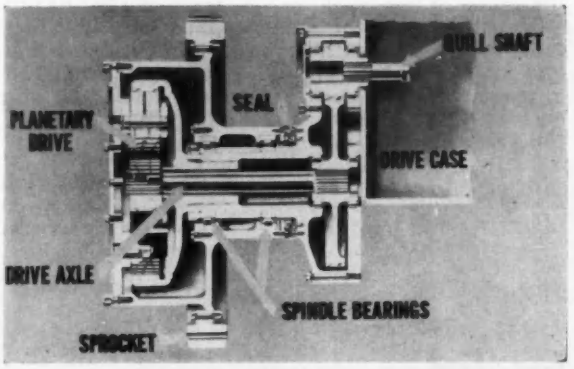

Fig. 1—Euclid TC-12 planetary and bullgear assembly.

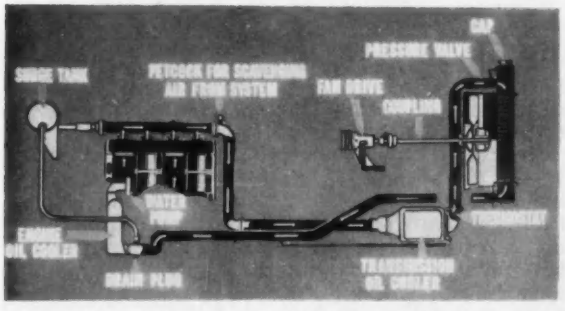

Fig. 2—The radiator is mounted to the rear of the driver instead of in front of the engine.

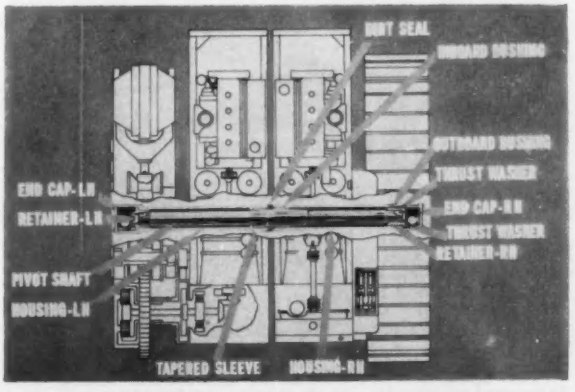

Fig. 3—Schematic arrangement of the TC-12. The pivot shaft assembly permits the two halves to rock with respect to each other.

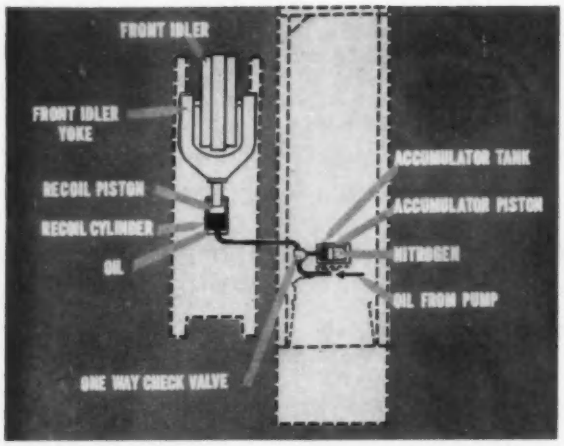

Fig. 4—TC-12 recoil system uses a large hydraulic cylinder instead of conventional spring-type mechanism.

mits some interesting operating characteristics. For example, one track can be thrown into forward with the other track into reverse, causing the tractor to pivot around its center rather than around the center of one track; or, one track can be thrown into neutral with the brake applied and the other track in either forward or reverse for a conventional type of steer. Steering can also be accomplished by controlling the two separate throttles on the engines. This gives excellent control under conditions requiring the maximum amount of power steering. It is not necessary to stop the tractor before shifting into reverse or forward. Shifting from one gear to the other is accomplished by clutching within the transmission, hence, shifting gears can be done without hesitation.

The recoil mechanism on the TC-12 is unique. (See Fig. 4). We do not use the conventional spring type recoil mechanism, but instead, we substitute a large hydraulic cylinder, which is connected to a nitrogen-charged accumulator. Oil from the transmission comes in under moderate pressure, approximately 100 psi, through a check valve. This pushes the piston in the cylinder forward and moves the idler forward, provided any slack has developed in the track. Pressure of the idler against the track is very low. Under conditions requiring recoiling, the idler starts backward. This closes the check valve and puts the hydraulic system under the pressure of the accumulator. As soon as the need for recoil has passed, the accumulator pushes oil back into the hydraulic cylinder and pushes the idler back into its original position.

The track rollers on the TC-12 are not the conventional type, as far as their bearing mountings are concerned, in all other respects, however, they are conventional. The bearings for the roller are outboard of the rollers. They are carried in housings, which bolt into the recesses that are machined in the roller frames. The Hyatt barrel bearings are used to support the rollers. Metal to metal seals are used to seal the rollers.

Based on one part of the paper on the Euclid tractor by R. C. Williams, H. C. Kirtland, and C. M. Jordan, presented at the SAE Golden Anniversary Tractor Meeting, Milwaukee, Sept. 13, 1955. For complete paper (in multilith form), write SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

Euclid Twin Tractor Styling . . .

. . . expresses "guts", gives the appearance of "leaning" into the load, and is functional in concept.

Based on paper by **C. M. Jordan,** Styling Section, GMC

THE Euclid twin tractor was styled to (1) increase the function of the tractor, (2) give maximum operator comfort and visibility, (3) improve accessibility to working parts, (4) obtain maximum compactness, (5) give the appearance of power and "guts." Comparison between conventional tractor styling and the TC-12 is shown in Fig. 1.

For maximum visibility the hood line was sketched in with a maximum slope downward to the front, and the rear shroud line with a maximum slope downward to the rear. Vertical lines were sloped forward, giving the appearance of leaning into the load or pulling. Body shapes were given a heavy, "well fed" look to convey weight and power. The hood—front guard—cowl shape was developed to convey the feeling of a charging bull with his head down. (See Fig. 2).

To simplify the shape of the rear portion of the TC-12, the battery box, tool box, and seat box were included in one secondary shape which was blended into the main shape of the radiator shroud. By designing a flat "sliced" surface at the rear end of the radiator shroud shape into which the radiator air exhaust opening is cut, the rear shroud reads as a heavy thick casting which has been machined straight across the back of the tractor to the side

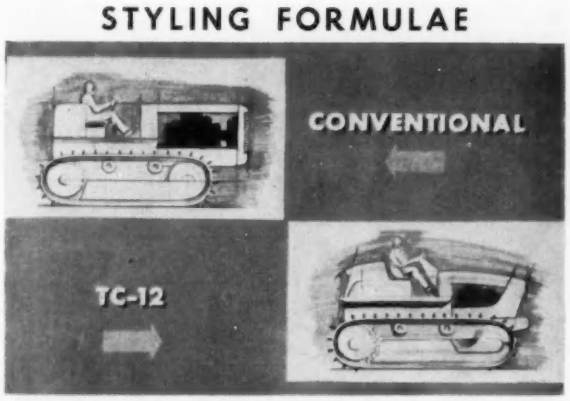

Fig. 1—Preliminary sketches of TC-12 styling specified that front hood and rear shroud lines have maximum slope to give operator good visibility.

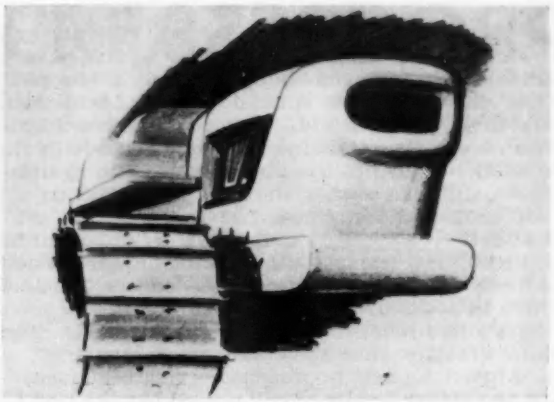

Fig. 2—Front end styling was developed to look massive, masculine and strong. Completely new look expressed the completely new engineering concept of the twin tractor.

profile lines. (See Fig. 3). To make the fenders look like they belong on a 58,000 lb tractor, the fender thickness was increased to 4 in. and designed hollow to house and protect hydraulic lines, in addition to adding rigidity to the basic frame structure of the tractor.

Each half of the tractor was designed as a complete shape in itself to play up the twin power concept. All openings cut into the basic shape of the tractor are flanged inward to make the shape around the opening look thick and solid.

The 9 louvers in the radiator shroud air exhaust opening were designed to appear massive and strong to go with the weight of the basic body shapes. The horizontal pattern ties in with the horizontal pattern of the tracks.

The headlight bar in the engine compartment ventilation opening was designed to be sharp, angular and massive to give a strong clear pattern in the opening from a distance. The headlights and backup lights were recessed for protection from falling objects.

An illustration of the over-all styling concept is shown in Fig. 4.

Based on one part of the paper on the Euclid tractor by R. C. Williams, H. C. Kirtland, and C. M. Jordan, presented at the SAE Golden Anniversary Tractor Meeting, Milwaukee, Sept. 13, 1955. For complete paper (in multilith form), write SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

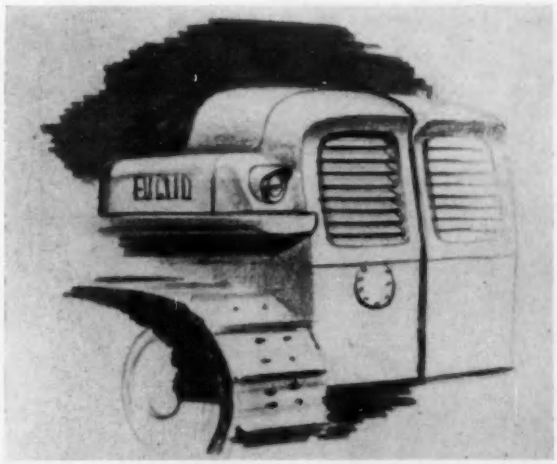

Fig. 3—Rear-end styling eliminates a weak look by the use of 4-in. thick fender and massive louvers in the radiator shroud air exhaust opening. After sketches, a 1/10th scale layout was made, then a clay model was sculptured.

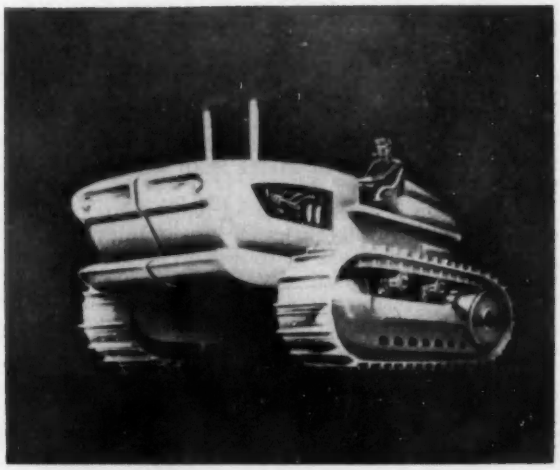

Fig. 4—Summary of preliminary sketches. A full scale layout and full scale clay and wood mock-up was made. Then, final design from the model was translated into a detailed surface drawing. Tooling was planned from these drawings and wood templates.

On The Land

Creative PATH to

PROGRESS in ground vehicle engineering comes largely from combining old ideas in new patterns, the 1956 SAE Annual Meeting held Jan. 9–13 in Detroit showed. Sessions evidenced this kind of creative thinking as applied not only to products but also to the instruments, testing techniques, and men used to develop the products.

Of course, the engineer has to have the "old" ideas first . . . a good grounding in the fundamentals of the physical sciences and in human nature. Then he needs specialized practical knowledge in the field where he seeks to solve problems.

These two requisites most engineers have. The really creative ones show two more attributes: a mind open to new approaches—even wild ideas—and the ability finally to cull out all but the best of the combinations of ideas.

These evidently are the talents which enabled engineers to come up with such innovations as a track-laying tire, a much more compact power steering mechanism, and a car body planned for our steadily aging population of drivers. No doubt the same talents were behind the synthesis of a mathematical substitute for the L-4 test of engine lubricants, a new recorder for timing crank angle at which combustion phenomena occur, and a railroad test car for studying stresses in locomotive structures—all described at the meeting.

Certainly these creative processes were in evidence when, during a symposium on education, automotive engineers struggled with the problem of increasing the number of their own kind.

In the case of the "track-laying" Rolligon tire, the wheel and suspension were incorporated into a big soft tire. As with tracks, the Rolligon's generous contact surfaces and consequent low bearing pressures float a vehicle over terrain surfaces that conventional tires would penetrate.

First Rolligons were friction driven by a series of rollers over their tops. At the Meeting, it was disclosed that Goodyear engineers have recently found ways to utilize axle drive and axle loading with the Rolligon. The result is more efficient use of power, extreme reduction of rolling resistance, and faster, lighter vehicles.

Recently, too, engineers have appropriated an old steamboat idea, the walking beam, and applied it to a suspension for use with Rolligons. This provides vehicle springing and shock absorption besides that inherent in the tire itself. It also allows use of a smaller tire diameter than would otherwise be required.

Experimental four-wheels-driven Army vehicles equipped with Rolligon tires and walking beam suspension perform feats in snow and sand impossible with conventionally tired vehicles. Predictions are that Rolligon tires combined with walking-beam suspensions will contribute greatly to the mobility of our military ground forces.

Chrysler engineers have taken the four now more-or-less conventional units of a power steering mechanism and have run them up the steering column. This novel arrangement conserves precious space

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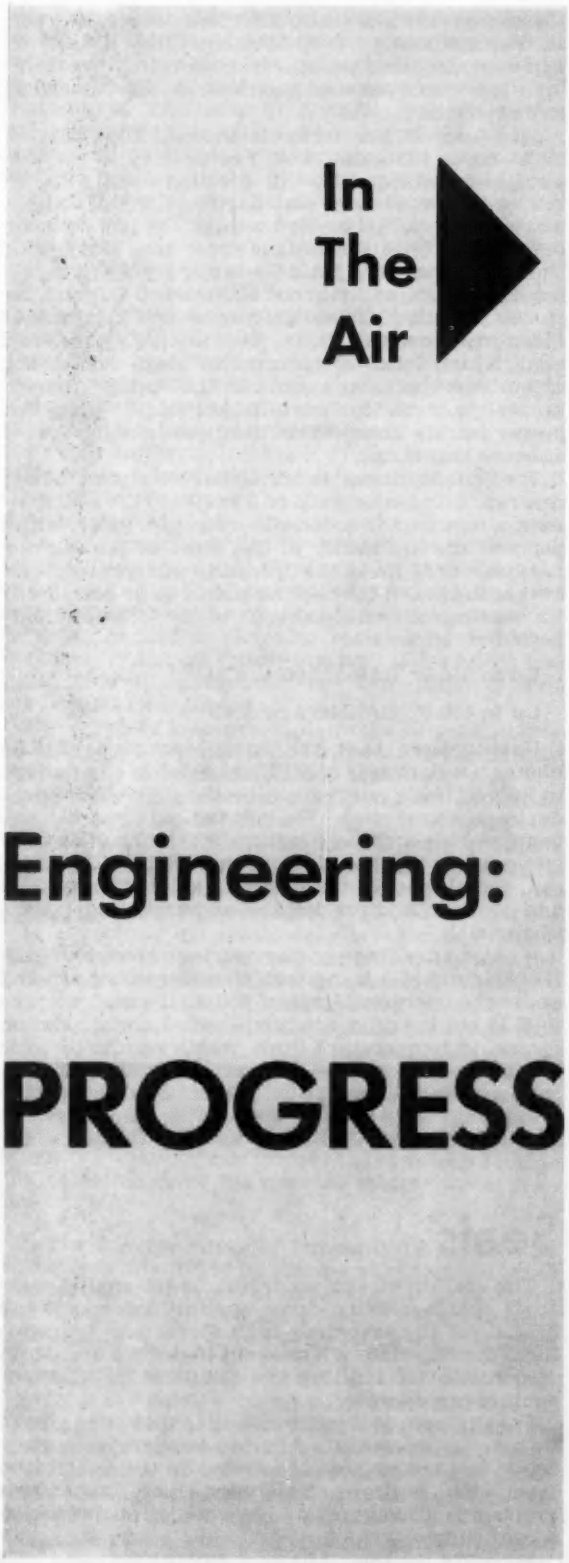
Based on papers and discussions presented at the



1956 SAE Annual Meeting (See pp. 80-81 for list of papers)

CREATIVE attack by aeronautic engineers to develop better materials bids fair to produce early fruits. Materials—and methods of handling them—seem to be the key to better efficiency and longer life for jet engines. And commercial airlines will demand these qualities when they start replacing their present equipment with jet-powered planes.

So, the work toward better materials for jet-engine parts revealed in papers at the 1956 Annual Meeting has particular significance at this time. Information on solution of materials problems was made available in connection with jet-engine bearings, seals, compressor discs, and turbine buckets.

Bearings

Engine people seemed to agree that the best opportunities for improving aircraft engines lie in metallurgical and lubrication research. It is in this direction, they feel, that large gains can be obtained in raising the:

1. Permissible operating temperature.
2. *Minimum* life of bearings, regardless of the wide spread between minimum and maximum.

Catalog ratings of standard rolling-contact bearings are based on the probability of 10% of the bearings failing. Such practice is not for aircraft engines. Engine damage caused by bearing failure can be extensive. The consequences will, therefore, be most serious, particularly for single-engine aircraft. Thus, for aircraft bearings, every effort must be made to achieve 100% reliability.

Lubrication—One discusser claimed that bearing material and fatigue life limit prolonged operation at 300 F. Others have found that the lubricating oil is the limiting factor. In any case, it is clear that the lubricants must meet very stiff high-temperature requirements. Military specifications also require the oil to meet certain low-temperature requirements. In addition, the oil is expected to serve as a heat exchanger medium to dissipate the heat generated by friction. A few lubricants, such as the synthetic oil, grade MIL-L-7808, are able to maintain their lubricating qualities in the –65 to 450 F range and also meet the other requirements. Unfortunately, they exhibit a tendency toward coking at the higher temperature. No other lubricants appear to be commercially available for higher operating temperatures if they must also lubricate at the lower temperature. It is possible to operate bearings at 600 F by feeding them with a small quantity of new oil, which goes through to waste instead of being recirculated. This means oil for lubrication only, without any cooling.

Metallurgy—The metallurgical requirements for a successful bearing include the selection of a material that will maintain its hardness after long-time exposure at the operating temperature. Some of the factors that are important in meeting these requirements are:

1. Composition.
2. Melting practice.
3. Heat-treatment.
4. Hardness.

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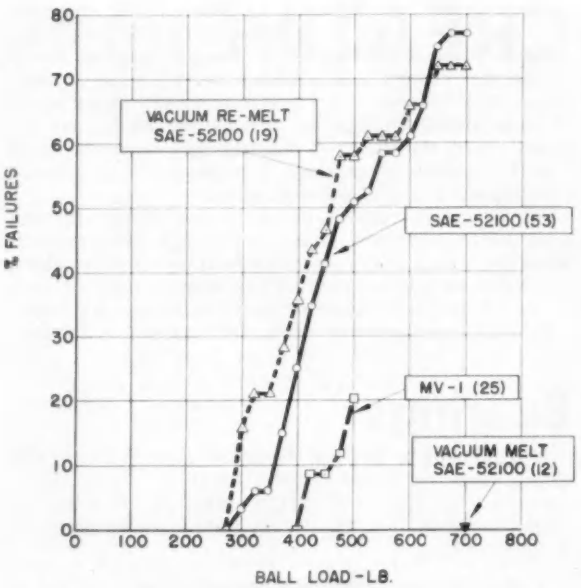


Fig. 1—One-ball fatigue tests on Barnes machine. Progressive loading of ½-in. balls, starting at 250 lb. Left-hand scale shows per cent of each lot tested that failed at indicated load.

Composition—Minor elements or impurities may have an important effect. This has been proved by the various modifications of the conventional 52,100 steel that have been tried. For instance, the L7 steel contained a little molybdenum to confer deep-hardening properties and a great many bearings were made of this steel at one time. It appears to have some advantage in the larger sections. Another modification, known as MHT, contains some aluminum. This is supposed to have a little higher temperature resistance, but it has not been shown to have better fatigue properties.

Vacuum Melting—Experiments with vacuum melting are giving both good and mediocre accounts of themselves, indicating that there is still much to learn about it.

Fig. 1 shows a distribution of fatigue failures in a ball fatigue machine for four kinds of steel. Of particular interest is the point at 700 lb that represents 12 balls of vacuum-melted 52,100 steel made from virgin material. None of these balls have broken up to 700 lb. It is this big increase in the minimum load for failure that promises such substantial gains through metallurgical changes.

The main reason why vacuum melting seems to offer these great possibilities is that it allows for the production of steel with a significant reduction of inclusions. Although the effect of inclusions on bearing performance has not been definitely established, it is generally recognized that inclusions can lower bearing life by promoting damage due to flaking fatigue. It appears that it is simply not possible to ensure a consistent inclusion content in air-melted steel.

Heat-Treatment—Dimensional stability of the bearing parts depends on proper heat-treatment. Other properties are also affected. Processes such as martempering, deep-freezing, and double or triple drawing may possibly be used to improve bearing life. Improvements here should help somewhat to increase life.

Hardness—It was formerly thought that bearing parts, especially balls, should be as hard as possible and that the capacity and life increased with an increase in hardness. But hardness seems to be a matter that can be carried too far. It has recently been shown that the fatigue limit goes along with the microelastic limit and the latter reaches a maximum at a hardness of about 56 Rockwell C in carbon steels, declining rather sharply as the hardness is increased above this value. Bearing tests have been made which seem to confirm this idea. Something of perhaps the same nature is the "brittle range," known to exist for certain materials. Superior properties are obtained at hardnesses either above or below this range.

The "hot hardness" is a criterion often used to help determine the suitability of a material for bearings. Assuming that the successful operation of a bearing depends on the ability of the steel to maintain a hardness of 60 Rc at the operating temperature, one author indicated that the materials to be considered for bearings to operate at each of the following temperature ranges are:

Up to 350 F: SAE 52,100 and MHT

Up to 450 F: HALMO and M-1

He indicated that the advantage of a slightly higher hot hardness of MHT material in comparison to SAE 52,100 is outweighed by the difficulty of producing a clean steel. He pointed out that in conventional air melting practices it is difficult to control consistently the cleanliness of this alloy. Reason, the aluminum has a strong affinity for oxygen and nitrogen and precipitates as harmful inclusions in the melt.

A chief advantage of the bearings produced from HALMO and M-1 is, he said, that they are tempered above the operating limit of 450 F. In contrast, the SAE 52,100 bearings are tempered at the maximum operating temperature limit, which results in their being very susceptible to overtemperature if they overheat during operation. Once they exceed the tempering temperature and soften, they do not maintain their load-carrying ability and soon fail.

Seals

The sealing of various media in jet-engine main shaft and accessory drive applications is difficult because of the extremely high speeds and temperatures encountered. Here again materials are partly responsible for limiting the temperature at which engines can operate.

For example, it is estimated that fuel pumps must be able to accomodate fuels at temperatures up to 500 F, created by heat absorption in the wing tanks from skin friction. This high fuel temperature problem is also aggravated by the use of the fuel as a heat sink.

Probably the most common rubbing material used in seals is carbon. Any of a number of materials

can be used to run against the carbon. Some of them, in the order of performance, are: chromium-plated steel, nitrided steel, carburized steel, and cast iron. The carbon material consists of various percentages of synthetic or natural graphite, pitch coke, lampblack, or calcined coal, compacted with a coal tar pitch binder. The carbon raw material may later be processed by infiltration with resins to fill the pores or with metals to augment surface action and increase strength. Some high-pressure liquid seals require a zero-porosity carbon, which is commonly achieved by multiple resin impregnations. The approximate limitations for these conventional running combinations are 600–800 F and a rubbing velocity of 350 fps, with proper lubrication. These limitations, plus the undesirable fragility and brittleness of carbon materials have convinced some seal engineers that alternate combinations of materials must be found for future use. Others aren't yet ready to discard carbon. They feel that ways can be found to protect the carbon in the seal, and it's worth while taking the trouble to do so. In fact, it was reported that carbons having special treatment to extend their ability to resist oxidation are represented as being stable to 1200 F. Impregnation of semiporous carbon materials with metals having high melting points and good thermal conductivity extends the useful range of carbons by reducing frictional heat and improving heat dissipation, because its heat conductivity is greater than that of the basic carbon material.

The problem is to develop an oil seal satisfactory for operation up to 1300 F. This resolves itself into discovering a combination of materials that are compatible while operating in a variety of media. One company reported that, to date, it had run over 725 tests using 420 different material combinations.

So far, they have found no material combination that appears to be completely satisfactory for the extremely high temperatures.

In all contacting seals, wear becomes a problem because rubbing occurs between the rotary and the stationary members. For this reason, extensive wear experiments at temperatures up to 700 F with carbon seal materials sliding against various metals are being undertaken. So far, the following results have been reached:

1. Wear of carbon materials was accelerated rapidly by operating at higher temperature levels. Increased wear appears to be related to the formation of visible oxide films on the mating metal surface.

2. The adverse effect of temperature on wear of carbon was minimized by the use of chromium plate as the mating surface. Chromium plate gave longer wear than type 347 stainless steel. M-10 tool steel gave higher wear than 347 at temperatures above 400 F.

3. In most cases impregnants were effective in giving some wear reduction. The relative effectiveness of impregnants changed with varied mating materials and at different temperatures. Chromium plate gave lower wear with all types of impregnated carbons than did 347.

Chrome-plated was also reported to give very good wear results by another speaker, who warned, however, that the temperature must now go above 600 F. At higher temperatures, he said, the chrome plate softened, so that other materials must be used.

Compressor Discs

The use of titanium in production gas turbine engines results in many headaches for the manufacturing department unfamiliar with its handling.

Titanium, often called the "wonder metal" because of its remarkable light-weight, high-strength characteristics, has been called some less glamorous names by those trying to put it into production.

They soon found that the properties of titanium required manufacturing processes and methods different from those normally used for the conventional steels.

For instance, in most cases it requires forming between 500 and 1000 F, which presents a special hot forming problem. Each alloy of titanium must be considered separately, since the proximity of the yield and the ultimate strength points vary from alloy to alloy and at different temperatures. Another concern is the change in elongation and reduction of area, which vary along the temperature range. Therefore, each operation for each part is a case in itself and the individual factors must be considered for titanium forming operations.

As an example of the problems encountered, let us consider some of the amazing things found in the manufacture of compressor discs from RC130B and Ti140A. For instance, early tests of physical property characteristics of compressor disc forgings indicated that billet acceptance tests, based on forged pancakes rather than contour forgings, were not completely reliable. Some billets, predicted to produce forgings of unacceptable durability, actually produced forgings of superior ductility, while the reverse was also found to be true. Mechanical properties and metallurgical changes to be expected in service, such as overaging, were also found to differ between specimens taken from actual forgings and those made from bar stock.

The use of vacuum-melted low-hydrogen billets improved ductility. It was eventually determined that the optimum forging practice required forging in one heat to the finished size. Since this procedure was not practical, reductions in the vicinity of 50% with a minimum number of reheats were used.

Certain critical components of turbojet engines were found to have developed time-fracture failures. Generally this phenomenon is attributed to press-fitted applications interacting with the high hydrogen content of the metal, resulting in brittle failure. This failure occurred in titanium alloys containing 0.015% hydrogen and over.

Vacuum annealing was, therefore, used to reduce the hydrogen content to acceptable levels. The discs were heated in a vacuum retort for 24 hr at 1225 F, at a vacuum level of one micron. This treatment reduced the hydrogen content of up to 0.035% to less than 0.0125%, with substantial increases in elongation and reduction in area.

Unfortunately, this created other problems. For instance, in vacuum annealing under these conditions, diametral shrinkage was encountered of

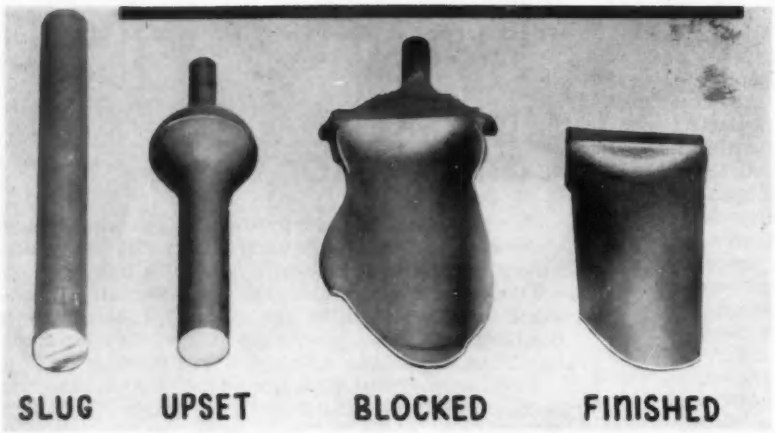


Fig. 2—Sequence of forging operations for producing turbine bucket.

0.0005 in. per in. of radius. This made it necessary to devise a method of salvaging parts with the undersize outside diameters.

Turbine Buckets

Turbine inlet temperature in excess of 1900 F dictates the necessity of using super alloys throughout the blading and vanes of the turbine. Special attention must be paid to the selection of the alloy used. It must have very high creep resistance in the first few stages and best fatigue properties in the last stage, which operates at a relatively low temperature.

Cost of manufacture and strategic alloy content should also be determining factors in the selection of the alloy to be used.

Table 1—Composition of GMR-235

Carbon	0.10 – 0.20
Manganese	0.25 max
Silicon	0.60 max
Chromium	14.00 –17.00
Iron	8.00 –12.00
Molybdenum	4.50 – 6.00
Aluminum	2.50 – 3.50
Titanium	1.50 – 2.50
Boron	0.025– 0.100
Nickel	Balance

Table 2—Chemical Composition of Jet-Engine Bucket Alloys

Alloy	C	Co	Ni	Cr	Mo	W	Cb	Ti	Al	Fe
S-816	0.40	42	20	20	4	4	4	—	—	4
M-252	0.15	10	53	19	10	—	—	2.5	0.75	4
Udimet 500	0.10	14	55	19	4.25	—	—	3	3	1
Inco 700	0.10	28	48	15	3	—	—	2.5	2.5	1

The manufacture of turbine buckets from both investment castings and precision forging was described.

The turbine buckets for the Allison T56-A-1 turboprop are made of the new nickel-base alloy GRM 235, which was said to be tailored just for this type of application. Its composition is given in Table 1.

Jet engine buckets are also made by precision forging (Fig. 2). Three nickel-base alloys and one cobalt-base alloy used in this work are M-252, Udimet 500, Inco 700, and S-186. Their chemical composition is given in Table 2.

Each of these alloys is susceptible to grain growth. Thus, they must be forged under closely controlled temperature conditions. It is necessary to maintain a high finish forging temperature on the dies and a low solution treating temperature to produce buckets of uniform grain size. The nickel-base alloys are more prone to a differential grain growth than the cobalt-base alloys. Therefore, they must be forged within a narrower range.

The trend in bucket alloys has been to more complex compositions, which makes conventional melting more difficult. It is generally agreed by the suppliers of high-temperature alloys that more heats are "lost" at melting than at any other point. Melting is the most critical point in the manufacture of these alloys. Heats that are not properly melted will contribute to cracking and/or high processing costs in the forging of buckets because of the presence of undesirable constituents. It is expected that vacuum melting of the present nickel-base alloys with aluminum and titanium additions will result in cleaner and more forgeable alloys with noticeable improvement in fatigue, stress-rupture, life, and ductility.

Vacuum melting of M-252 has resulted in longer stress-rupture life and improved ductility and forgeability. The overall properties of vacuum-melted M-252 are superior to air-melted M-252. However, in order to reduce the spread in values of vacuum-melted M-252, further intensive work is being done with the melted technique itself as well as the conversion of ingots to bars. Since vacuum melting is still a relatively new method of producing high-temperature alloys on a production basis, it is only a matter of time before these objectives are accomplished.

PROGRESS continued from page 74

around the engine and uses space that would otherwise be wasted.

The four elements of the power steering unit are:

1. Piston and valve assembly—The piston holds the porting discs for the spool valve. The hardened, ground spool valve slides inside the porting discs.

2. Ball and nut bearings—The recirculating ball nut assembly changes steering wheel rotary motion into linear motion for shifting the spool valve during power operation or for manual steering when power is off. Its extremely low friction gives the steering unit a very silky feel to the driver.

3. Hydraulic reaction assembly—This is the "feel" unit. It transmits pressure from the power unit back to the steering wheel to give the driver a "feel" proportional to the steering effort. It also connects the steering wheel to the spool valve.

The driver, by turning the steering wheel, shifts the spool valve. The hydraulic system then does the work of steering the car by making the piston follow the spool valve.

4. Rack and gear sector—This changes the linear motion back to rotary motion. The gear sector shaft swings the pitman arm to turn the front wheels.

These elements in the coaxial configuration constitute the current Chrysler production power steering unit.

The configuration of the body itself might well be revised to meet the needs of older drivers and passengers, which constitute an ever increasing proportion of the total motoring population, several speakers urged. Older people appreciate doors of greater height. Higher doors make it easier for the less nimble to get in and out of cars. One way mentioned to achieve added door height is to style the car roof with "butterfly" extensions at the sides. By contrast with today's roof cross-sections, the butterfly roof top would be flat or even slightly convex. The upturned sides would provide 2–4 in. more at door tops.

Older drivers tend to have more difficulty in accommodating the muscles of their eyes to switch focus from one distance to another. So, it was further suggested, moving the instruments farther forward of the driver would enable older drivers to adjust their focus from instrument dials to the road faster. Indicator faces would, of course, have to be marked with correspondingly larger characters.

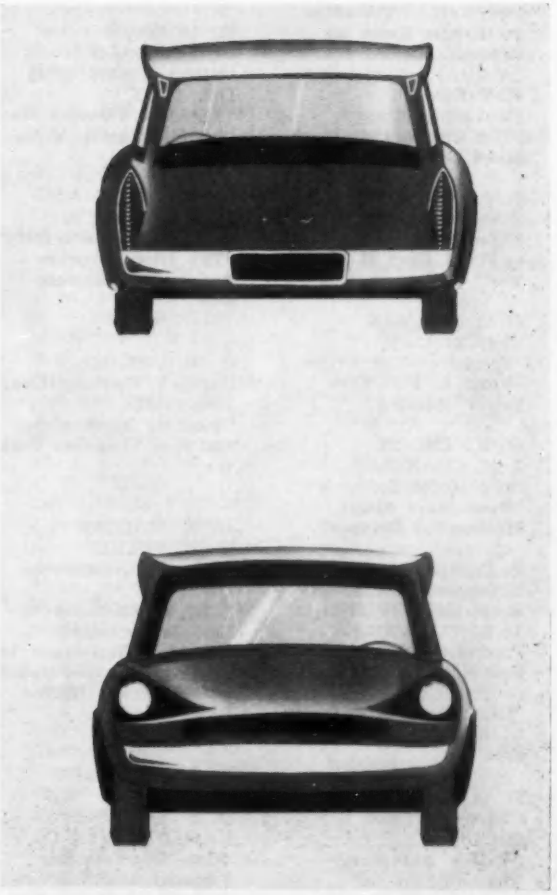
A crash safety expert advocated moving instruments and windshield farther forward for another reason—so that in case of impact the head of a front-seat passenger whose torso was restrained by a lap belt would swing forward into empty space instead of striking the dash or glass. Or if the head did strike, there would be a fraction of a second more for the rapidly diminishing impact energy to dissipate itself in the car structure.

Just as "creative" as the thinking reported on products were the thoughts advanced on testing techniques and instruments.

One statistically minded lubricants man even outlined a simple mathematical procedure for calculating the L-4 rating of an engine oil as precisely, he claimed, as the engine can measure in the standard L-4 laboratory test. He has developed factors for base oils and for additives, which when multiplied by the per cent contained in the finished oil, can be added up to give the L-4 rating.

He didn't start out to devise a mathematical substitute for the test—and he considers it only a check on actual test results for spotting bad engine runs and validating good runs. He started out to find what L-4 characteristics should be retained in a replacement for the somewhat outdated L-4 test. What he did was to apply statistical techniques to L-4 data on 120 tests run on various production lubricants over a seven-year period. He concluded, among other things, that:

• The new test should retain the general method of rating the dirtiness of the various engine parts



"BUTTERFLY" ROOF would permit higher doors that would make it easier to get in and out of car. They would also provide strong structural side members and space for elevated stop and turn lights.

PAPERS ON GROUND VEHICLE SUBJECTS presented at 1956 SAE Annual Meeting included:

R. R. BOCKEMUEHL
E. F. WELLER
Research Laboratories Div., GMC
"An Instrument for Recording the Cylinder Pressure vs. the Crank Angle of an Internal Combustion Engine"

R. R. BURKHALTER
P. J. MAZZIOTTI
Dana Corp.
"The Low Silhouette Drive Line"

A. J. CHENEY
W. B. HAPPOLDT
K. G. SWAYNE
E. I. du Pont de Nemours and Co., Inc.
" 'Zytel' Nylon Resin and 'Teflon' Tetrafluoroethylene Resin as Bearing Materials"

H. F. COPP
Ford Motor Co.
"The Continental Mark II—A Design Story"

R. J. DeGRAY
Standard Oil Co. (Ohio)
"The Chevrolet L-4 Test —'What Does it Measure' "

O. D. DILLMAN
Chrysler Corp.
"Precision—The Prime Factor in Full-Time Power Steering"

OTTO ENOCH
J. M. CHANDLER
Ford Motor Co.
"Once More About Mechanical Octanes"

F. B. FISCHL
Enjay Laboratories Div.,
H. H. HOROWITZ
T. S. TUTWEILER
Products Research Div., Esso Research and Engineering Co.
"Cold Starting With V. I. Improved, Multigrade Oils"

H. O. FLYNN
Chevrolet Motor Div., GMC
"A New Automatic Transmission for Chevrolet Heavy Duty Trucks"

C. J. FORD
L. U. G. NILSSON
Goodyear Tire and Rubber Co., Inc.
"Goodyear Rolligon Tires—A New Approach to Vehicular Mobility"

R. S. FRANK
W. J. LUX
Caterpillar Tractor Co.
"A Billion Engine Hours on Aluminum Bearings"

D. N. FREY
Ford Motor Co.
"New Material Processes for the Automotive Gas Turbine"

K. W. GAGE
P. J. RHOADS
Detroit Transmission Div., GMC
"The New General Motors Hydramatic Transmission"

R. J. GORSKY
Buick Motor Div., GMC
"The New Dynaflow Automatic Transmission"

C. W. LINCOLN
Saginaw Steering Gear Div., GMC
"Steering Mechanisms and How They Got That Way"

G. K. MALONE
T. W. SELBY
Research Laboratories Div., GMC
"The Relationship of Low Temperature Cranking Resistance to Viscosity Characteristics of Multigrade Engine Oils"

R. L. OVERCASH
W. HART
D. J. McCLURE
Kendall Refining Co.
"How Do Volatility, Viscosity and V.I. Improvers Affect Oil Consumption?"

LUDVIG PETERSEN
Electro-Motive Div., GMC
"Field Testing of Diesel Locomotives for Strength and Performance"

R. J. POCOCK
Ford Motor Co.
"Wear—Where and When"

N. M. REINERS
W. E. WOOLLENWEBER, JR.
Cummins Engine Co., Inc.
"Turbocharging High Speed, High Output Diesel Engines"

F. A. ROBBINS
The Koppers Co., Inc.
R. W. SENIFF
Baltimore and Ohio Railroad Co.
"Full-Scale Field Service Tests of Railroad Diesel Fuels"
(Report of the Analysis of the Group on Full-Scale Field Service Test of Railroad Diesel Fuels of the Coordinating Research Council, Inc.)

D. M. SEVERY
J. H. MATHEWSON
Institute of Transportation and Traffic Engineering, University of California at Los Angeles
"Technical Findings from Automobile Impact Studies"

J. A. WARREN
J. B. HINKAMP
Ethyl Corp.
"New Instrumentation for Engine Combustion Studies"

R. L. WEHE
Cornell University
"Brake Ratings for Automotive Vehicles"

Symposium—Education for Automotive Engineering

E. C. EASTON, Dean of Engineering
Rutgers University
"Basic Factors Affecting the Design of Engineering Curricula"

M. C. HORINE
Mack Mfg. Corp.
"Looking Ahead in Automotive Engineering Education"

T. L. PREBLE
Tide Water Associated Oil Co.
"Evaluation of Professional Requirements of the Automotive Engineer"

R. L. STANLEY
Diesel Engine Manufacturers Association
"Survey of Internal Combustion Engine Courses Offered by Colleges and Universities of the U. S."

Symposium—Lengthening Intervals Between Preventive Maintenance Inspections

A. A. DACH
Chestnut Farms—Chevy Chase Dairy Co.
"Effects of New Lubricants on Stretching Out Preventive Maintenance Intervals"

J. H. DOLAN
Burlington Truck Lines, Inc.
"Tightening Up a Preventive Maintenance Program"

E. B. OGDEN
Consolidated Freightways, Inc.
"Reconditioning of Vehicle Components, Condition vs. Mileage or Hours"

Papers on Ground Vehicles—continued

Symposium—Fan Horsepower Losses and Noise and Their Reduction

K. A. BEIER
Schwitzer-Cummins Co.
"Some of the Reasons for Inefficient and Noisy Automotive Fan Installations"

D. F. LEMAUX
GMC Truck and Coach Div., GMC
"Temperature Controlled Fans"

R. W. WANTIN
Ford Motor Co.
"Automatic Fan Control"

J. H. BOOTH
Thompson Products, Inc.
"Hydraulic Fan Drive"

H. A. REYNOLDS
Harrison Radiator Div., GMC
"Effect of Fan Design on Cooling Index Horsepower and Noise"

The Next Decade and the Automobile

Part I—The Engine
E. T. VINCENT
F. L. SCHWARTZ
University of Michigan

Part II—The Chassis
CHARLES LIPSON
University of Michigan

Part III—The Body
A. H. LAHTI
University of Michigan
U. O. LAHTI
Consultants to Management, Inc.

PAPERS ON AIRCRAFT SUBJECTS presented at 1956 SAE Annual Meeting included:

G. C. BARNES
Pratt and Whitney Aircraft Div., United Aircraft Corp.
E. A. RYDER
Consulting Engineer
"A Look at Some Turbine Bearing Problems"

RAYMOND CAPIAUX
Convair Div., (Fort Wayne), General Dynamics Corp.
"A Method for Correcting Existing Jet Engine Performance"

H. E. CARD
R. L. MATHIAS
Aviation Gas Turbine Div., Westinghouse Electric Corp.
"Foreign Object Ingestion in Turbojet Engines"

E. H. DAVISON
Lewis Flight Propulsion Laboratory, National Advisory Committee for Aeronautics
"Compressor and Turbine Matching Considerations in Turboprop Engines"

S. G. DEMIRJIAN
Aircraft Gas Turbine Div., General Electric Co.
"Wrought Jet Engine Bucket Alloys"

D. K. HANINK
Allison Div., GMC
"Engineering Requirements for Jet Engine Materials"

J. L. McCABE
J. L. LaMARCA
Aircraft Gas Turbine Div., General Electric Co.
"Problems Related to Introduction of Titanium into Production Turbojet Engines"

JOHN PRESTON
J. MOGUL
G. K. FLOROFF
Wright Aeronautical Div., Curtiss-Wright Corp.
"Anti-Friction Bearing Materials for Aircraft Powerplants"

Symposium—Turbine Engine Maintenance and Overhaul Costs

N. R. PARMET
Trans World Airlines, Inc.
"Turbine Engine Overhaul Problems—A Challenge to the Air Transport Industry"

V. L. SCHATZ
A. L. WYNN, JR.
R. W. REMKE
Aircraft Gas Turbine Div., General Electric Co.
"Jet Engines—What Price Power"

COL. C. W. SMITH
U. S. Air Force
"Accelerated Service Testing of Turboprop Engines in USAF Test Bed Aircraft"

Symposium—High Temperature Dynamic Seals

R. W. BLAIR
Chicago Rawhide Manufacturing Co.
"Controlled Gap Seal"

T. C. KUCHLER
J. W. PENNINGTON
E. J. TASCHENBERG
Metal Products Div., Koppers Co., Inc.
"High Speed High Temperature Shaft Seals"

R. L. JOHNSON
M. A. SWIKERT
J. M. BAILEY
Lewis Flight Propulsion Laboratory, National Advisory Committee for Aeronautics
"Wear of Materials for High Temperature Dynamic Seals"

JOSEPH PALSULICH
R. RIEDEL
The Cleveland Graphite Bronze Div.
Clevite Corp.
"Dynamic Seals for Aircraft Gas Turbine Engines"

J. B. STEVENS
Sealol Corp.
"Current Status of Axial Face Seals"

Procedures, Inspection, and Equipment Relating to Airline Maintenance"

JONAS ANDERSON
Wright Aeronautical Div., Curtiss-Wright Corp.
"Preignition in Aircraft Reciprocating Engines"

W. A. BECK
Dow Chemical Co.
"Weld Repair of Aircraft Quality Magnesium Castings"

A. D. EDWARDS
Delta-C and S. Airlines
"Radiography of Aircraft Structure for Safety and Economy"

Producibility

B. K. BUCEY
Boeing Airplane Co.
"Recent Developments in Airframe Manufacturing Methods"

C. R. KRAMER
A. KASTELOWITZ
Republic Aviation Corp.
"Forgings and Modern Fighter Airplane Producibility"

R. H. LUNDBERG
Chance Vought Aircraft, Inc.
"The Learning Curve Theory As Applied to Production Costs"

and combining these figures into a composite figure.

- The fuel should be better standardized.

- Bearing weight loss should be determined so that it measures loss due solely to the action of the oil or its deterioration products.

- The rating system should be changed so that error is either independent of rating, or proportional to the rating.

For studying processes within engine combustion chambers several new instruments were reported. One of them, Ethyl's crank angle-time recorder, combines the previously announced total surface-ignition counter with other electronic devices to make a permanent record of the time in crank-angle degrees at which certain engine phenomena take place. It serves, for example, to time the arrival of normal or surface-ignited flame fronts at the ionization gap.

The crank angle-time recorder can make use of the ionization signal received by the total surface-ignition counter to trigger a spark generator which jumps a spark between an electrode and a crankshaft-driven cylinder covered with sensitized paper.

Another imaginative combination of electronic building blocks into special-purpose instrumentation was a selective counter described in an account of Electro-Motive's new test car for measuring locomotive strain and performance. The selective counter will record both intensity and frequency. If it's used to tabulate in-service strains, it provides a strain history useful for predicting part life.

The device will count impulses from a strain gage bridge, a differential transformer, or any similar circuit. The input is fed into a balance control through a calibrator break-in jack into the input transformer. The input transformer signal goes, via attenuators and amplifiers and a rectifier and filter, into four trip tubes. An output of 150 v operates the first trip tube; 200 v operates the second trip tube; 250 v the third; and 300 v the fourth. As each trip tube fires, a light shows also on the front panel so that it alerts the operator. For the permanent record, the firings of each tube are counted on individual digital counters. Also, output from the selective counter can be recorded on an oscillograph.

Creative thinking need not be confined to objects of rubber and steel and glass, the Meeting proved. It produces equally worthwhile results when applied to the management of people. For example, creative engineering management has undoubtedly contributed to the practicality of Chevrolet's new truck transmission. When Chevrolet's truck engineering group absorbed a number of engineers from a passenger car group, someone had the bright idea of putting all the newcomers through truck drivers' training. As a result, those of the men who eventually went into transmission work were well equipped to judge what features would prove most useful in their product.

The Chevrolet heavy-duty truck transmission was described in a paper presented at the Meeting, as were the 1956 versions of the Hydra-Matic and the Dynaflow. All three papers appear in abridged form elsewhere in this issue of SAE Journal.

Applying creative thinking to the problem of recruiting and training more engineers, participants in a symposium on engineering education came to these conclusions:

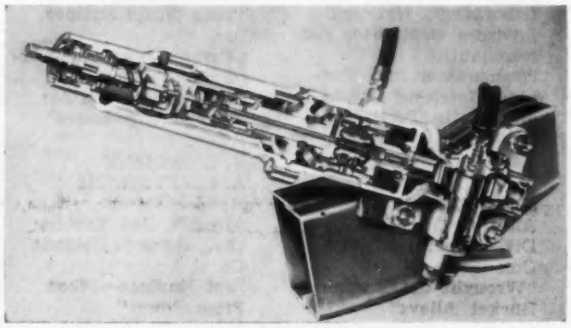
- The place to reach engineering prospects is in the high school. Industry can help by acquainting both teachers and students with the requirements and rewards of the profession.

- Industry can help also by encouraging better teaching of the basic physical sciences in high schools . . . both by opening the doors of industrial laboratories to teachers for tours and possibly part-time work and by furnishing teaching materials and speakers.

- The well rounded engineer combines a thorough knowledge of the basic physical sciences with specialized knowledge of the practices in his own field. The college serves best when it concentrates on educating the budding engineer in the scientific fundamentals he's sure to be using throughout his working life. It's industry's role to furnish the specialized up-to-date training that finishes the job of making an engineer out of the graduate.

One recurring note in the symposium's discussions was the feeling that the bases of remunerating both educators and engineers need change. To get better teaching in both high schools and colleges, we must make teaching financially attractive to well qualified people. To interest more and better high school students in preparing for engineering careers, we must assure them by example that their salaries will compare with those paid by other professions—not only during engineers' first years out of school but also as they mature in their chosen work.

ROLLIGON TIRES AND WALKING BEAM SUSPENSION give this Army vehicle good traction and smooth ride.



CHRYSLER POWER STEERING UNIT is coaxial with steering column. Result is saving of scarce space in engine area.

continued from page 17

Annual Meeting Reflects

Creative Engineering

Study of Integration of Design and Automation." It was an unusual session . . . and its chairman was Ford's Del S. Harder, credited with having brought the word "automation" into the language of modern manufacturing.

The annual business session of the Society was held preceding the technical sessions on Tuesday, January 10. The brief address by 1955 President C. G. A. Rosen was a feature this year.

'55 President Rosen Announces

Council Decides to Move SAE Headquarters to New Offices in New York City

485 Lexington Ave.

President Rosen made this announcement at the Annual Business Session of the Society, on January 10, during Annual Meeting.

LAST fall, Council reaffirmed its faith in the ability of SAE to meet the challenge expressed throughout our Golden Anniversary year . . . that of furnishing even greater service—in breadth, in depth, and prestige—to automotive engineers. It has done so by authorizing the moving of SAE headquarters to new, more adequate quarters in New York City.

A lease has been signed for these new quarters, in a new building at 485 Lexington Avenue, which will be ready for occupancy during the latter part of this year. Council sees these new quarters as a necessary tool in equipping the Society with effective facilities for continuing and extending SAE services immediately and in the future. These new offices will furnish SAE with the headquarters equipment to satisfy growing needs and take advantage of new opportunities to serve as they emerge.

To these broad considerations, which pointed to a need for more adequate headquarters facilities, were added several more specific considerations which pointed in the same direction. Among the more important of these were:

1. Headquarters space is already inadequate. Within a year or two, the Society's continued growth will make it impossibly small. (This despite the fact that headquarters personnel has increased only from 85 to 91 since 1950, while membership has gone up from 14,850 to 20,422.)
2. There is no chance of getting expanded space in the Engineering Societies Building.
3. The whole future of the Engineering Societies Building itself is uncertain. It may be torn down, sold, renovated or left as it is—and NOBODY can even guess which . . . or when.
4. In addition to added space being necessary within the near future, more suitably arranged and more modern space, it is believed, will contribute to increased efficiency of operation.

Council based its decision to make the move on these main considerations. The building at 485 Lexington Avenue was selected as the most suitable for SAE headquarters from a considerable number of buildings that were investigated.

Annual Meeting Reflects CREATIVE ENGINEERING

Automotive Executives Dramatize Management, Automation Problems

Formal part of the automation session was presided over by SAE Vice-President E. H. Kelley (left), who ran the Production Activity's business session, and D. S. Harder, session chairman.

"JUST like in my company!" chorused many of the more than 400 engineers at the dramatized automation session. It was the most frequently heard, enthusiastic tribute to the results of this unusual presentation.

The dramatization, entitled "A Case Study of Integration of Design and Automation," was a satire on how unenlightened management can hamper engineering and manufacturing and endanger a company's competitive position. It portrayed the plight of the executives (shown on the next page) of the mythical Heliotrac Co. It dramatized the plagues created by lethargic management direction, lack of planning, and uncoordinated operation of key functions.

The session format delivered effectively the message planned by the SAE Passenger Car and Production Activities, the groups which sponsored the session. The message:

1. Automation demands higher-than-ever coordination between Engineering and Manufacturing, and understanding of Management.
2. Design programs must be planned for years ahead, and be integrated with automation equipment which involves heavy capital investment.
3. Automation isn't a cure-all for every problem, needs to be specially tailored to each individual situation.

Session Chairman D. S. Harder expressed the atmosphere of the session when he said: "Although the Heliotrac Co. is a mythical one and its product hypothetical, the problems that its executives face are very real. Arch Colwell and his cast will enact here today a scene that has taken place in hundreds of companies and will continue to take place. I know, because I have been in on many such meetings."

The play was performed in two acts.

ACT I

The first act, in the office of Heliotrac's executive vice-president A. T. Colwell (in real life vice-president of Thompson Products), revealed that the company was on the brink of disaster. The pressure from a foreign competitive product, the obsolescence of the product's design, and management's resistance to investing in modern machine tools had brought a serious drop in sales.

Sales manager C. L. Hecker, manufacturing manager L. I. Woolson, chief engineer E. N. Cole, and purchasing agent F. E. Farrell demonstrated how management's conservativeness plus their associates' unwillingness to cooperate stymied progress.

The "players" added to the realism of the situation with well-documented arguments and spirited interchanges, each blaming the others for his troubles.

The sales manager accused the chief engineer of not creating a salable product. . . . The engineer blamed management for lack of funds to do research and development and to hire engineers

Dress Rehearsal

ON the morning preceding their actual performance, the cast spent more than three hours putting the finishing touches on their play. Director Colwell put his players through their paces, as shown in the photos at right, and acquainted Session Chairman Harder with the plot.

Adding to the realism of the play was the opportunity for improvisation given each performer. Though the plot was carefully outlined, players were not restricted to prescribed lines. Instead, each man was permitted to express the ideas in his own words. Director Colwell reasoned that his amateur players would be comfortable with their parts and more impressive if they would "live" their parts in the performance, rather than memorize lines written for them.

At the rehearsal, the cast took pains to plug any holes in the technical phases of their play which their audience of engineers might detect. Director Colwell also instructed his cast in the subtle techniques of projecting their ideas as well as their emotions to the audience . . . to slightly exaggerate their play-acting so as to present a living cartoon. Rehearsal also gave the cast an opportunity to familiarize itself with the stage setting and props for the actual performance.

The theatrical tradition of "poor dress rehearsal, wonderful first night" didn't hold true in this case. Both were fine. And if the players had first-night jitters, it wasn't apparent.

Sales manager practices how to be indignant.

Executives of the mythical Heliotrac Co. were enacting roles not far removed from the actual company responsibilities each has actually borne. They are, left to right: Sales Manager C. L. Hecker (first vice-president of Oliver Corp.); Manufacturing Manager L. I. Woolson (president of DeSoto); Executive Vice-President A. T. Colwell (vice-president of Thompson Products); Chief Engineer E. N. Cole (chief engineer of Chevrolet); Vendor D. D. Robertson (vice-president and director of sales of Spicer); and Purchasing Agent F. E. Farrell, (assistant director of automotive sales of Bendix Aviation Corp.).

for the job. . . . The purchasing agent claimed the manufacturing manager wanted to make parts that could be made cheaper and better by vendors, and pinned responsibility on the engineer for a water pump that nobody could make. . . . And the manufacturing man harped on management's parsimony with dollars needed for up-to-date machinery.

ACT II

With the problem identified in the first act, Heliotrac's executives returned to a "6-weeks-later" second meeting in the closing act. Each came up with a well-planned program in his own area for curing Heliotrac's ills.

Called in for advice, supplier D. D. Robertson showed how he could furnish a modern automatic transmission, at a reasonable price, to replace Heliotrac's outmoded manual shift job. Now harmony, a spirit of cooperation, and a sense of pulling together as a team blossomed. Heliotrac's future looked bright as the skit ended.

SAE Activities Cooperate

This Passenger Car-Production Activity session was the culmination of nine months of planning and active work by many in addition to the performers. For instance, Meetings Vice-Chairman of the Production Activity, E. O. Wirth, headed a group of men who outlined the "plot." In further developing the script and directing the play, SAE Past-President Colwell was assisted by Errol Gay, E. F. Gibian, and C. W. Goldbeck. And among the others who furnished important help were Lee Bowling, of Chevrolet, and Joseph Coughlin, of DeSoto.

Proof that this effort paid off was twofold. The audience received it enthusiastically. . . . And there was widespread interest from newspapers, magazines, radio, and television.

Leading engineering and manufacturing executives at the speakers' table joined in the applause for a job well done.

The full script of the Heliotrac case study will be published in SAE Journal's Annual Production Issue in May.

This is where the supplier is introduced.

Director Colwell sets the situation . . .

. . . and coaches his cast in their lines.

TECHNICAL Board says "Well Done" to 29 . . .

OUTSTANDING contributions to SAE Technical Committee work brought certificates of recognition to 29 members of SAE technical committees following the Technical Board Luncheon during the Annual Meeting.

Recipients of the certificates of appreciation from the Board this year in recognition of outstanding contributions to SAE technical committee work were:

M. G. Beard
Aeronautics Committee
W. W. Reaser
Aeronautics Committee
W. H. DuBois
Aeronautics Committee
A. E. Raymond
Aeronautics Committee
A. W. F. Green
Aeronautics Committee
A. E. Smith
Aeronautics Committee
R. P. Loveland
Aeronautics Committee
R. W. Young
Aeronautics Committee
C. L. Sadler
Aeronautics Committee
N. F. Rooke
Aeronautics Committee
G. W. Brady
Aeronautics Committee
W. A. Siler
Automotive Drafting Standards Committee
H. L. Rittenhouse
Construction & Industrial Machinery Technical Committee
J. H. Boiles
Electrical Equipment Committee
W. E. Swenson
Engine Committee
E. R. Pierce
Engine Committee
M. D. Gjerde
Fuels & Lubricants Technical Committee
J. D. Klinger
Fuels & Lubricants Technical Committee

CITATIONS WERE READ by 1955 Technical Board Chairman Charles C. Chayne (center). The members so honored received their certificates from the hand of 1956 SAE President George A. Delaney (left). Looking on is 1956 Board Chairman Robert F. Kohr (right), who opened the luncheon program.

THE INCOMING SAE PRESIDENT has a busy time at the Annual Meeting. . . . Helping to present Technical Board certificates, for instance, (see left above) was but one of many activities of 1956 President George A. Delaney at the 1956 Annual Meeting.

He also sat in on a meeting of the executive committee of 1955 President C. G. A. Rosen's Council, said words of encouragement and greeting to the Student Committee, the Meetings Committee, the Sections Committee, and other assorted member groups . . . spoke at the Annual Meeting Dinner, attended the last meeting of the 1955 Council . . . and took over as 1956 president by presiding at the first session of the 1956 Council on the last day of the Meeting.

In between times, he attended several technical sessions, participated in informal conferences preparatory to various formal meetings, and generally swung into the Presidential saddle as 1955 President Rosen swung out.

R. P. Lewis
Hydrodynamic Drive & Transmission Committee
L. A. Danse
Iron & Steel Technical Committee
E. H. Stilwill
Iron & Steel Technical Committee
Hyman Bornstein
Iron & Steel Technical Committee
R. N. Falge
Lighting Committee
R. E. Carlson
Lighting Committee
G. W. Laurie
Transportation & Maintenance Technical Committee
T. L. Preble
Transportation & Maintenance Technical Committee
B. F. Jones
Truck & Bus Technical Committee
C. C. Saal
Truck & Bus Technical Committee
J. E. Gray
Tube, Pipe, Hose & Lubrication Fittings Committee

At Annual Meeting Dinner

SECRETARY of the Army Wilber M. Brucker paid high tribute to SAE in his major address at the Annual Meeting Dinner on Wednesday evening.

"It is extremely heartening to me, as Secretary of the Army," he said, "to know that the membership of the Society of Automotive Engineers is still fully mobilized for service to the Nation . . . that SAE's invaluable help can be depended upon at all times in solving the myriad, new and thorny problems besetting our Army in this atomic age."

Brucker was the headliner at one of the Society's most successful dinner programs. He was introduced to the more than 2000 engineers by Robert L. Biggers, president, Fargo Division, Chrysler Corp. 1955 SAE President C. G. A. Rosen presided over the program, following an opening welcome to the guests by Detroit Section Chairman K. R. Herman.

Delaney Seeks "The Best"

George A. Delaney, in his inaugural address as SAE President for 1956, emphasized the need for a healthy dissatisfaction with mediocrity in every attack on SAE problems. "SAE is great," he said, "because its members have never been satisfied with anything except the best of everything."

He voiced his belief that the time has come to relate more closely to SAE's operating problems the general elements of guidance given by the Society's Constitution. Then he went on to spell out how specific objectives for operating programs might be better focused and restated . . . bringing out many of the points made in his article titled "The Best of Everything" which was a leading feature in the January 15, 1956 (ROSTER ISSUE) of SAE Journal.

Brucker Details America's Challenge

America today faces an unprecedented challenge, Brucker believes . . . and he emphasized that the Army's importance has not been diminished by the advance of modern technology. "Its ability to carry out its combat mission is, in the final analysis, still the true measure of our national security."

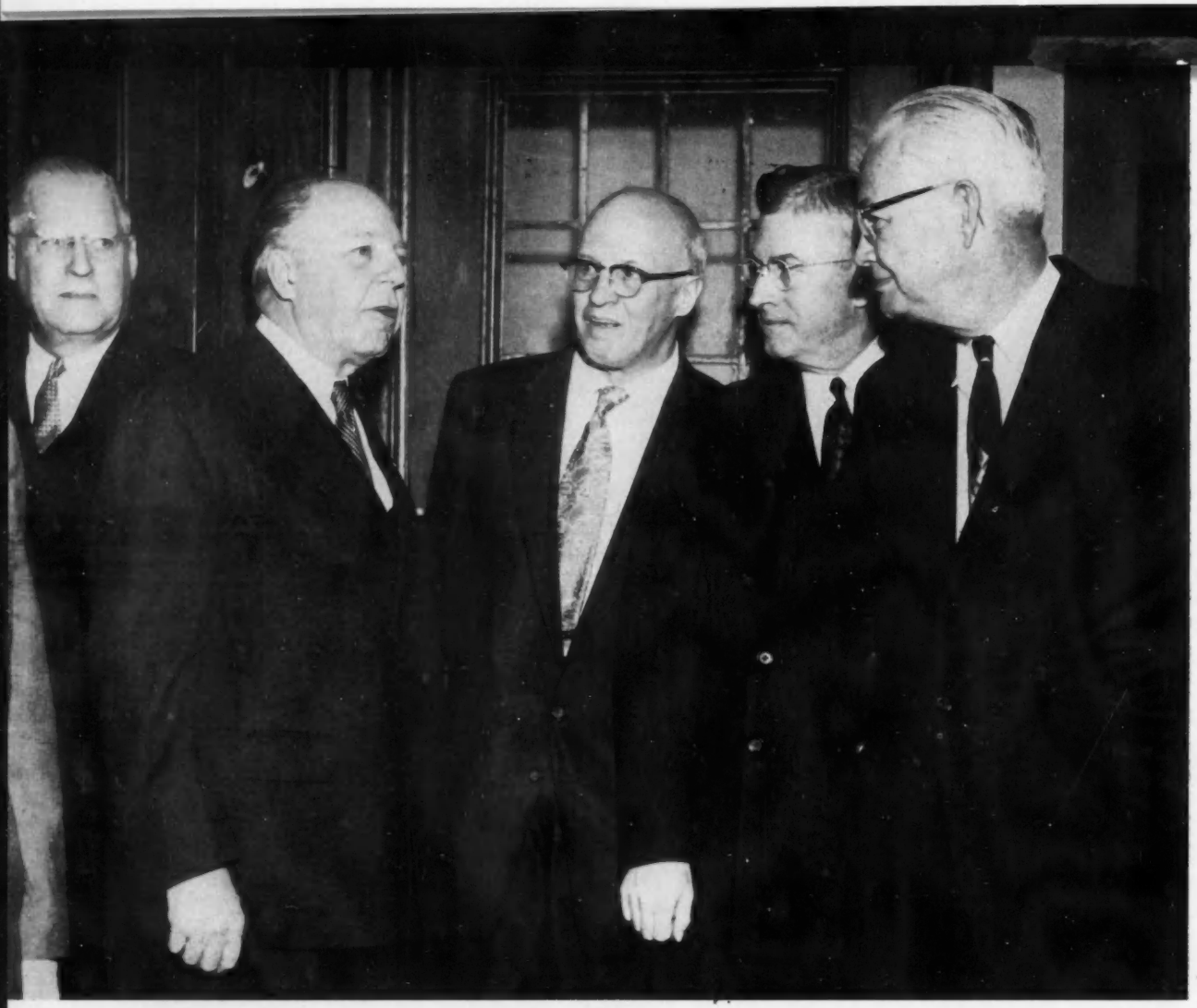
It would be inviting disaster, Brucker continued, to assume that unlimited nuclear war is the only kind likely to occur. Then he went on to say in part:

"The idea that a war can be won by merely pushing buttons is a dangerous illusion. To embrace the concept that victory can be achieved by remote control is to invite defeat. The belief that machines are making war easy and safe for the men who fight can lead only to a psychological, spiritual, and physical unpreparedness for the realities of military conflict.

"Within the broad field of mobility—an area of primary interest to a large majority of the members of the SAE—are found some of the Army's most challenging problems.

"It is our purpose to make the Army as fully air-transportable as possible. The feasibility of flying ground troops directly between continents was dramatically demonstrated recently in the course of rotating two Regimental Combat Teams. With the cooperation of the Air Force, one of these units of great striking power was flown all the way from Fort Bragg in North Carolina

Annual Meeting Reflects Creative Engineering



PARTICIPANTS IN THE DINNER PROGRAM gathered to greet Secretary of the Army Wilber M. Brucker (second from left) prior to the beginning of the speaking schedule. Brucker was the chief speaker at the Dinner. Others who spoke were (left to right): Robert L. Biggers, who introduced the Secretary; 1955 SAE President C. G. A. Rosen, who presided; 1956 SAE President George A. Delaney, who made his inaugural address; and Detroit Section Chairman K. R. Herman, who welcomed the guests to Detroit.

to Japan, and a unit of equal size and power was flown from Japan to Fort Bragg. This entire, gigantic, two-way operation was accomplished in only 10 days.

"We feel encouraged to believe that what was done with a Regimental Combat Team can be done with an entire division—and in one lift—a matter of hours—if the day comes when it is imperative to move larger units similar distances with maximum speed. It is of vital consequence to America that the Army be in a position to transport sizable troop units by intercontinental air lift on very short notice.

"The Army has an equally intense interest in planes which can land or drop ground troops within a combat zone, prepared to go into instant action. They are essential if we are to "get there first with the most." For instance, a fleet of C-119 "Flying Boxcars" could lift the entire assault element of one airborne division at one time, and drop it on the battlefield as much as 750 miles from its base. The effectiveness of our intrepid paratroopers, dropping from the sky upon the enemy, has been brilliantly proved in two wars.

"It is important, however, that we also be able to utilize in airborne operations troops which have not been trained in the specialized techniques of descent by parachute. A new assault transport, the C-123, now in limited production, can take off from and land on ordinary unimproved fields with 60 men and their individual equipment. Small groups can be efficiently moved by the Army's own light cargo helicopters—1½ ton cargo craft—each of which can transport between 14 and 18 men, depending upon their equipment. The Army has on order larger helicopters for the movement of troops and supplies within the combat area.

"The committees of the SAE have performed yeoman service in helping to bring our equipment to its present level of versatility and dependability, but many critical problems remain to be solved. For example, a reduction in the weight of all equipment is mandatory in order to facilitate the strategic and tactical movement of units by air, and to minimize our surface transportation requirements. We foresee steady increases in firepower, but unfortunately any increase in firepower in most cases is accompanied by an increase in the weight of the equipment involved—launching platforms, transporters, gun tubes.

"A real technological breakthrough which would make possible more powerful, but at the same time lighter weapons, would result in marked increase in the Army's basic mobility and would have a far-reaching effect on almost all aspects of our combat vehicle programs. Further technological advances are also required in power plants, fuels, and running gear in order to reduce the requirements of a field army for logistical support. It is essential, too, that the development of heavy construction equipment keep pace with the development of combat materiel, and that ease of movement be as high priority a consideration in this area as in any other."

At the Speakers Table Were:

W. J. CRONIN, Managing Director, Automobile Manufacturers Association.

COL. ROGER HEMION, Commanding Officer, Detroit Arsenal.

DON BERLIN, President, Piasecki Helicopter Corp.

C. J. REESE, President, Continental Motors Corp.

DR. A. T. COLWELL, SAE Past-President.

STUART G. BAITS, Vice-President, General Manager, Hudson Special Products Div., American Motors Corp.

G. A. DELANEY, 1956 SAE President.

K. R. HERMAN, Chairman, SAE Detroit Section.

DR. A. W. HERRINGTON, SAE Past-President.

DR. C. G. A. ROSEN, 1955 SAE President.

WILBER M. BRUCKER, Secretary of the Army.

ROBERT L. BIGGERS, President, Fargo Div., Chrysler Corp.

DR. C. F. KETTERING, SAE Past-President.

ALVA W. PHELPS, Chairman of the Board, Oliver Corp.

REAR-ADMIRAL A. G. MUMMA, Chief, Bureau of Ships, Department of the Navy.

C. A. CHAYNE, Vice-President, Engineering, GMC.

CAPT. CHARLES R. WATTS, USN, Staff Director, Standardization, Office of the Assistant Secretary for Defense.

DR. J. C. ZEDER, SAE Past-President.

COL. WILLARD F. ROCKWELL, Chairman of the Board, Timken - Detroit Axle Div., Rockwell Spring & Axle Co.

ALLEN B. CROW, President, Economic Club of Detroit.

COL. J. G. VINCENT, SAE Past-President.

DALE ROEDER, SAE Past-President.

R. J. S. PIGOTT, SAE Past-President.

DR. ARTHUR NUTT, SAE Past-President.

RECEPTION BEFORE THE DINNER

RECEPTION FOR SPEAKERS TABLE GUESTS brought together many of the chief executives of the automobile and aeronautic industries, important military and governmental personnel and 15 SAE Past-Presidents. Those who were seated at the Speakers Table are listed in the column at the left.

J. B. JOHNSON, Chief Scientist, Aeronautical Research Laboratory, WADC.

COL. J. C. SHINKLE, Acting Chief, Ordnance Research and Development Div., Department of the Army.

ROBERT CASS, SAE Past-President.

ROBERT M. CRITCHFIELD, Vice-President, Pontiac Motor Div. GMC.

W. S. JAMES, SAE Past-President.

R. R. TEETOR, SAE Past-President.

DR. JOHN A. C. WARNER, Secretary and General Manager, Society of Automotive Engineers.

D. G. ROOS, SAE Past-President.

COL. O. J. BALDWIN, Chief, Procurement Div., General Staff, Department of the Army.

WILLIAM LITTLEWOOD, SAE Past-President.

C. N. SAYEN, President, Air Line Pilots Association.

C. E. FRUDDEN, SAE Past-President.

J. H. HUNT, SAE Past-President.

KARL ROESCH, General Manager, Autocar Div., White Motor Co.

W. W. SMITH, Manager, Aviation Gas Turbine Div., Westinghouse Electric Corp.

EVENTS
At Annual Meeting

HORNING MEDAL was presented to Bernard M. Sturgis (right) for his paper, "Some Concepts of Knock and Anti-Knock Action," presented at the SAE National West Coast Meeting, Aug. 18, 1954. This paper was adjudged by the Horning Medal Board of Award as "the best contribution to existing knowledge in the art of mutual fuel and engine adaptation" that was presented at an SAE meeting during 1954. . . . A. O. Willey (left), chairman of the 1954 Horning Memorial Board of Award, made the presentation.

AT THE BUSINESS SESSION of the Society on Tuesday evening, 1956 SAE President George A. Delaney received a standing salute from the audience on the occasion of the official announcement of his election.

MORE THAN 70 COMMITTEES met and made progress on SAE technical and administrative work during the 1956 Annual Meeting . . . and, in addition, there were hundreds of informal get-togethers in preparation for the formal meetings.

ROBERT CASS (left) was presented with Life Membership in the Society. Cass was SAE President in 1953 and completed his term on the Council as Past-President at the end of 1955. The presentation was made on behalf of the Society by 1955 SAE President C. G. A. Rosen (right).

THE FILM "SAE SUCCESS STORY" was shown on four separate occasions during the 1956 Annual Meeting and drew new plaudits at each showing. Originated, developed, and produced as a television program broadcast from the 1955 Aeronautic Meeting at Los Angeles, the film shows how SAE, over its 50-year history, has contributed greatly to aviation progress. Running about 15 minutes, the film was the product of thousands of man-hours of creative and spontaneous effort on the part of the San Diego Section under the direction of F. Herbert Sharp. . . . The television broadcast was made by Richfield Oil Co. on its regular "Success Story" broadcast.

. . . The film has already been shown before several SAE Sections, particularly to those West of the Mississippi . . . and is available for showing to any section on request. (Hollister Moore, manager, Membership and Sections Division, at SAE Headquarters, is the man to ask.)

★ ★ ★

NUCLEAR ENERGY ADVISER to the SAE President, A. J. Pomeroy, made his first "in person" report to SAE Council at its January 13 meeting. (Pomeroy's mission, started last June, is to keep SAE alerted to phases of nuclear energy development in which the Society might see possibilities of expanded service to its members.) . . . .

Reporting, Pomeroy showed that nuclear energy will play an ever greater part in areas related to SAE's technical interests. He reported results to date of his "keeping-abreast" activities . . . including stimulation of several papers, preparation of reports brought to members in SAE Journal, and discovery of possible areas of future technical committee interest. . . . In addition, he reported his observations made at the international atomic energy conference in Geneva last September. There, he noted that the Russians are not very far behind the United States in development of nuclear powerplants for electrical power generation.

★ ★ ★

Chairman at the 25 technical sessions held at Annual Meeting were: **P. C. Ackerman**, Chrysler Corp. . . . **W. B. Bergen**, Glenn L. Martin Co. . . . **H. F. Copp**, Ford Motor Co. . . . **F. E. Carroll, Jr.**, United Aircraft Products, Inc. . . . **Trevor Davidson**, Bucyrus-Erie Co. . . . **W. Paul Eddy**, Pratt & Whitney Aircraft Div., United Aircraft Corp. . . . **Robert Gardner**, Regular Common Carrier Conference of American Trucking Associations. . . . **R. W. Goodale**, Standard Oil Co. of Calif. . . . **C. C. Hudson**, Tennessee Valley Authority. . . . **D. S. Harder**, Ford Motor Co. . . . **R. F. Kohr**, Ford Motor Co. . . . **J. F. Kunc, Jr.**, Esso Research and Engrg. Co. . . . **W. C. Lawrence**, American Airlines, Inc. . . . **R. P. Lewis**, Dana Corp. . . . **W. W. McClintock**, Pan American World Airways, Inc. . . . . . **F. R. Nail**, Mack Mfg. Corp. . . . **R. C. Norrie**, Kenworth Motor Truck Corp. . . . **A. L. Pomeroy**, Thompson Products, Inc. . . . **Leonard Raymond**, Socony-Mobil Oil Co. . . . **T. M. Robie**, Fairbanks, Morse and Co. . . . **F. A. Robbins**, Koppers Co., Inc. . . . **R. A. Terry**, Creative Industries, Inc. . . . **S. J. Tompkins**, Chrysler Corp. . . . **A. F. Underwood**, Research Laboratories Div., GMC. . . . **G. P. Townsend**, Denver Div., Sunstrand Machine Tool Co.

★ ★ ★

1941 SAE PRESIDENT A. T. COLWELL reported to the Tuesday evening dinner gathering of SAE Past-Presidents concerning the decisive action taken by an efficiency expert examining a government bureau.

The efficiency expert first asked one distinguished looking man-behind-a-desk: "What do you do?"

Promptly came the reply: "Nothing."

The expert then asked the same question of another equally distinguished looking man-behind-another-desk.

Promptly came the same reply: "Nothing."

At which, the expert rose to decisive action: "That's highly inefficient duplication of work." he cried. "One of you has got to go!"

★ ★ ★

SESSION SECRETARIES were: **E. J. Bodensieck**, Thompson Products, Inc. . . . **R. H. Briggs**, Eaton Mfg. Co. . . . **J. E. Charipar**, Chrysler Corp. . . . **E. B. Cooper**, Chrysler Corp. . . . **J. R. Farnham**, Chrysler Corp. . . . **C. W. Goldbeck**, Thompson Products, Inc. . . . **T. J. Harris**, American Airlines, Inc. . . . **J. T. Hendren**, Pan American World Airways, Inc. . . .

. . . **Henry Jennings**, Fleet Owner. . . . **J. D. Leslie**, Fisher Body Div., GMC. . . . **D. Q. Marshall**, General Electric Co. . . . **John Moxey, Jr.**, Sun Oil Co. . . . **J. A. Miller**, California Research Corp. . . . **T. C. Noon**, Thompson Products, Inc.

. . . **W. J. O'Donnell**, Republic Aviation Corp. . . . **R. B. Palmer**, Ford Motor Co. . . .

. . . **C. B. Rawson**, Commercial Car Journal . . . **M. M. Schall**, Dana Corp. . . . **P. J. Sperry**, International Harvester Co. . . . **R. L. Strickland**, Detroit Aluminum and Brass Corp. . . . **G. S. Tobias**, Esso Research and Engineering Co. . . . **Leonard Westrate**, Commercial Car Journal . . . **L. H. White**, Ford Motor Co. . . . **H. D. Young**, Sinclair Research Laboratories . . . **W. W. Young**, Diesel Publications, Inc.

Reception Before the Dinner

REPORTERS—more than 60—from technical and business magazines and daily newspapers attended the Annual Meeting in Detroit. Three press conferences were held. But the largest number of news stories derived from the meeting came from private interviews and "sitting in" technical sessions.

The Press

NEWS about the SAE Annual Meeting in Detroit (Jan. 9–13) continued to flow to the public in spite of a strike that kept Detroit newspapers off the streets. This was accomplished through the media of radio and television. Detroit citizens who have been starved for news for many weeks have been turning to their radio and television sets during the strike as their only contacts with the outside world. As a result the many radio and television news spots and special programs about SAE found a large "captive" audience.

THROUGHOUT THE WEEK (Jan. 9–13) short reviews of noteworthy happenings at the SAE Annual Meeting were broadcast on the 5, 6, 10:30 and 11 pm radio news broadcasts over NBC station WWJ.

ON JAN. 9 television stations WWJ - TV (NBC) and WJBK - TV (CBS) broadcast film clips taken at an SAE-sponsored press conference about automobile crash test results on their 6 and 11 pm newsreels.

ON JAN. 10 WJBK-TV's 11 pm newsreel featured a press conference with the participants of the Production Activity's session on Automation. WWJ radio, in addition to several spots on its regular newscasts, also broadcast a special hour program on tape taken at the Automation drama-session Tuesday afternoon. The ABC-TV station in Detroit also televised a short film clip of the session on its evening TV newscast.

ON JAN. 11 the outstanding news at the meeting was Secretary of the Army Brucker's speech at the SAE Annual Dinner. At a press conference previous to the dinner, the Secretary described a recent trip he and his staff made to the Far East inspecting Army installations. His observations about the Army's preparedness to resist aggression from an enemy nation were quoted on several radio and television newscasts.

ON JAN. 12 a special half-hour television program was produced by Detroit's educational television station WTVS. Dr. C. G. A. Rosen, 1955 SAE president, Harry E. Chesebrough, ex-

TOP MANAGEMENT of the imaginary Heliotrac Co. was filmed in action during the Production Activity session for broadcast later over television station WWJ-TV. Also, a full hour edited version of the drama was broadcast on tape over WWJ radio. . . . Cast members were interviewed before curtain time by the newspapers, trade magazines, radio and television reporters. Film clips of the press conference and session appeared on NBC, CBS, and ABC television newsreels after the show. (The full story of this well-publicized feature of the meeting appears on pages 84 and 85.)

Meets S·A·E

ecutive engineer, product planning, Chrysler Corp., and Siler Freeman, writer for Crowell-Collier Publications were interviewed. They discussed Chesebrough's drawings of futuristic passenger cars and Dr. Rosen emphasized SAE's role in bringing modern cars and aircraft into being. Dr. Rosen also expressed his views on the need for more creative engineers and the responsibility of educational institutions to produce them.

ON JAN. 13 George A. Delaney, SAE's 1956 president and E. N. Cole, Chief Engineer, Chevrolet Motor Division, GMC, were guests on a special television show entitled "Car of Tomorrow" over WWJ-TV. This half hour live and film telecast pointed out how the car and aircraft of tomorrow are derived from the technical work that SAE members are doing today. More than half of this broadcast was devoted to showing and discussing special films taken at the Production Activity's drama-session on automation.

In reply to a question by NBC commentator James Clark, President Delaney reminded listeners of SAE's extensive activity in fields other than that of passenger cars and emphasized the benefits derived from an exchange of technical knowledge by engineers working in many different areas.

When asked how SAE cooperated with universities and colleges, President Delaney referred to the more than 4000 SAE enrolled students and pointed out that SAE technical publications are available in public and university libraries throughout the world. He said, "The SAE technical paper of today is the textbook of tomorrow."

In addition to radio and television coverage, the SAE Annual Meeting was attended by members of the automotive and aeronautic press. More than 60 reporters from magazines and newspapers were present at technical sessions, interviewed engineers privately, and attended press conferences. Information obtained at this meeting will appear in the trade press during the next few months and will supply background material for feature articles of the future.

PRESS CONFERENCE with the Honorable Wilber M. Brucker, Secretary of the Army and SAE's principal speaker at the Annual Meeting dinner, brought up-to-date news of the Army's preparedness for resisting aggression, based on the Far Eastern tour Brucker had just completed.

AUTOMOBILE SAFETY was the subject of a press conference. H. F. Copp, Ford Motor Co. (left) and D. M. Severy, Institute of Transportation and Traffic Engineering, UCLA were interviewed following Severy's presentation of a technical paper at a session of which Copp was chairman.

About SAE Members

Ogle

Tipton

Hopkins

Prevost

Hart

Fontaine

Best

McBeth

Oldberg

Lynch

Garrett

LeMay

SIDNEY OLDBERG has been named director of automotive research by Eaton Mfg. Co. His headquarters will remain in Detroit.

Oldberg has been in charge of the company's research and development engineering at the Detroit laboratory since 1945.

FRANK W. LYNCH, who has represented Tyson Bearing Corp. in the Detroit area since 1950, has been appointed in charge of the company's recently established Automotive Division in Detroit. This new division of Tyson Bearing, a subsidiary of SKF Industries, Inc., will provide service for tapered roller bearings to the automotive concerns in Detroit and nearby areas.

J. C. GARRETT, former president and founder of the Garrett Corp., has been elected chairman of the board. He has been president of the organization since 1936 when the corporation was founded. Under his direction the corporation has grown to nine divisions and three subsidiaries.

E. G. LeMAY has been elected president and director of Century Controls Corp. He has been serving as general manager.

JOHN E. DRAKE, formerly chief engineer, has been elected vice-president and director.

EDWARD F. MUTZ is now located at the Naval Civil Engineering Research and Evaluation Laboratory, Port Hueneme, Calif. He is serving as mechanical engineer in the design of naval field and construction equipment.

Mutz was test engineer for General Electric Co., Schenectady, N.Y.

EMERSON D. OGLE has recently been appointed regional manager by SKF Industries for the Eastern region, comprising the territories served out of the company's Boston, Hartford, New York, and Philadelphia offices.

Ogle has been assistant sales manager for SKF in Philadelphia.

J. H. TIPTON has been appointed regional manager by SKF Industries, Inc., for the Central Region, comprising the territories served out of the company's Buffalo, Cleveland, Cincinnati, Detroit, and Pittsburgh offices.

Tipton has been district manager for SKF in Cincinnati.

HOWE E. HOPKINS has been appointed technical administrator, Diesel Division, Continental Aviation and Engineering Corp., Detroit. He was formerly staff engineer, Turbine Division.

ALBERT A. PREVOST is now serving in the Overseas Operations Department of International General Electric Co., Schenectady, N. Y. He is concerned chiefly with the organization and operation of manufacturing facilities abroad.

Prevost has been making an aviation survey in Europe throughout 13 countries on behalf of the Aircraft Gas Turbine Division of GE, in his position as consultant.

He is also a member of the French Societe des Ingenieurs de l'Automobile.

LT. PETER J. HART is now serving with Army Ordnance at the Aberdeen Proving Grounds in Maryland. He is on a military leave of absence from his position as staff engineer for the New York City Omnibus Corp.

A. P. FONTAINE has been elected vice-president for engineering and a member of the administration committee of Bendix Aviation Corp. He has been director of engineering for the corporation.

PAUL W. BEST, JR. is now sales manager, Original Equipment Division, O. A. Sutton Corp., Wichita, Kan. He had previously been application engineer, Fractional Motor Division, Robbins & Myers, Inc. of Springfield, Ohio.

Before serving with Robbins & Myers, he spent 14 years with Redmond Co., Owosso, Mich., and then became general sales manager of Hupp Corp. in Detroit.

CARROLL R. McBETH has been appointed assistant to the executive vice-president of Holley Carburetor Co., Detroit. He joined Holley in 1941 as an engineer and in 1952 was appointed quality control manager.

Chrysler Engineering Reorganization Involves Many Prominent SAE Members

Zeder

Ackerman

JAMES C. ZEDER, Chrysler Corp. vice-president in charge of engineering, announces the creation of a new organizational structure for the Chrysler Corp. Engineering Division. The most notable feature of this new organization plan is the establishment of the Engineering Division as a self-contained unit under the vice-president—Engineering and operated by the newly created position of director of engineering.

This new organizational plan, creating a strong level of middle management positions from which promising young men can be developed, involves many SAE members.

PAUL C. ACKERMAN has been named to the newly created position of director of engineering, immediately under the vice-president. Ackerman, who joined Chrysler Corp. in 1934, has held the post of executive engineer since 1953.

Chesebrough

Exner

Huebner

Lamb

Loofbourrow

Pfeiffer

Steding

Named to the newly-formed Engineering Executive Committee, top administrative and policy-making group for the division, are Ackerman, as chairman, and as executive engineers: **HARRY E. CHESEBROUGH,** product planning; **CLIFFORD B. DOTY,** body; **VIRGIL M. EXNER,** director of styling; **GEORGE J. HUEBNER, JR.,** research; **ERNEST P. LAMB,** administration; **ALAN G. LOOFBOURROW,** chassis, electrical, and truck engineering; **KARL PFEIFFER,** laboratories and vehicle testing; and **H. RICHARD STEDING,** management planning.

R. H. SMITH, as manager, management planning, will report to H. Richard Steding, executive engineer, *management planning.*

L. R. BAKER continues as director of Chrysler Institute.

Reporting to H. E. Chesebrough, executive engineer, *product planning,* are members **J. C. GUENTHER,** manager, product planning; **N. B. CHRISTIE,** assistant manager, data coordination, **H. A. BUCHANAN,** section administration; and staff safety engineer, **R. C. HAEUSLER.**

Reporting to Virgil M. Exner, director of *styling,* are members **CARL REYNOLDS,** assistant director of styling; **S. L. TERRY,** chief styling engineer; **J. E. CHARIPAR,** engineer in charge—advanced projects; and **R. W. SINKO,** administrative services.

Reporting to C. B. Doty, executive engineer, *body engineering,* are members **J. W. SHANK,** chief engineer, body engineering; **G. E. BENYA,** deputy chief engineer at Outer Drive Engineering; and staff engineer **FRANK WALTER,** planning and schedules. On the Body Design Staff are staff engineers **HERMAN W. SMITH,** advance body development and body in white, and **W. J. CLARK,** body interior and front end metal.

Reporting to A. G. Loofbourrow, executive engineer, *chassis, electrical, truck engineering,* are members **R. R. NOBLE,** chief engineer, truck design development; **D. F. TOOT,** chief engineer, chassis design; **I. C. McKECHNIE,** chief engineer, electrical; **K. W. GORDON,** assistant chief engineer, truck design; **O. J. WINKELMANN,** assistant chief engineer, advanced component design; **O. D. DILLMAN,** assistant chief engineer, advanced chassis design; **A. J. SYROVY,** assistant chief engineer, advanced transmission design; **W. A. MULHERN,** assistant chief engineer, chassis component design; **R. S. RAREY,** assistant chief engineer, engine design; **J. L. GILMOUR,** assistant chief engineer, special projects; **J. W. DUHN,** assistant chief engineer, electrical laboratories; **T. R. KILGOUR,** assistant chief engineer, electrical laboratories; and staff engineers **R. M. SINCLAIR,** chassis, electrical, truck; **A. F. STAMM,** truck; and **C. M. WRIGHT,** standards.

Reporting to Karl Pfeiffer, executive engineer, *laboratories and vehicle testing,* are **M. F. GARWOOD,** chief engineer, materials laboratories; **W. E. DRINKARD,** chief engineer, general laboratories; **H. M. BEVANS,** chief engineer, vehicle testing; **H. L. WELCH,** assistant chief engineer, power plant; **W. R. RODGER,** assistant chief engineer, chassis; **T. C. GLEASON,** assistant chief engineer, body and suspension; **L. M. BALL,** assistant chief engineer, car dynamics; **A. W. STECKLING,** assistant chief engineer, proving ground; **O. M. RAES,** assistant chief engineer, truck development testing; and staff engineers **T. M. BALL,** consultant; **L. X. CHAPIN,** forward planning, organization; **P. D. MARRINER,** forward planning, product; **P. M. ROTHWELL,** laboratories and vehicle testing, and **W. E. ZIERER,** technical data.

Reporting to George Huebner, Jr., executive engineer, *research,* are **C. R. LEWIS,** chief engineer, nuclear research; **W. E. JOMINY,** chief research metallurgist, **S. B. TWISS,** assistant chief engineer, chemical research; **D. M. BORDEN,** assistant chief engineer, gas turbine research; **R. N. JANEWAY,** assistant chief engineer, automotive research; and staff engineer **J. R. LEMON,** engineering improvements committee.

ROBERT E. WILKIN of Hooker Electrochemical Co., Niagara Falls, N. Y., has been elected to the company's board of directors. He has also been named vice-president and director of sales. Wilkin was formerly vice-president and general sales manager for the company.

Active in SAE for many years, Wilkin is a past chairman of the Chicago Section.

I. W. ROBERTSON is now on the sales staff of Standard Products Co. in Detroit. He recently served with the Dryden Rubber Division of the Sheller Mfg. Corp.

KEITH W. TANTLINGER is now with Waterman Steamship Corp. as director of engineering research. He is concerned chiefly with the coordination of steamship and trailer operations and the designing and procuring of equipment for those operations.

He has been associated with Brown Trailers, Inc. as vice-president of engineering.

LOWELL W. SYVERSON has accepted a position with Four Wheel Drive Auto Co., Clintonville, Wis., as a senior design engineer. He has been a test engineer for Continental Motors Corp.

CLARKE T. GOETHEL is now a project engineer with Lear-Romec Division of Lear, Inc. He was formerly with the Diesel Equipment Division of GMC.

RICHARD H. SIMPSON, previously with Electric Auto-Lite Co. as a test engineer, is now serving in the same capacity with Clark Equipment Co., Jackson, Mich.

DR. ROBERT E. WILSON, president of Standard Oil Co. of Indiana; and **CYRUS R. SMITH,** president of American Airlines, Inc.; served as representatives of the field of transportation at the 1956 centennial observance of Rand McNally & Co., Inc. This "Chicago Assembly" in Chicago on Jan. 5 and 6 featured an "Inquiry Into the Challenge of a Changing World" by outstanding spokesmen for industry and education.

The assembly closed with a luncheon meeting devoted to transportation, with Dr. Wilson as chairman and C. R. Smith as speaker.

R. M. RUSSELL has been appointed manager of the new Hughes Products Division of Hughes Aircraft Co. The division will have the responsibility for making the products created by the company's research activities more widely available to industry.

Russell was general manager of the Gas Turbine division of Continental Aviation and Engineering Corp.

DR. FRANK N. PIASECKI, who recently established the Piasecki Aircraft Corp., International Airport, Philadelphia, has been initiated into honorary membership in the Epsilon chapter of Tau Beta Pi fraternity at New York University. He is a graduate of the University's Guggenheim School of Aeronautics.

LAWRENCE J. MATTHEWS, previously design engineer for J. I. Case Co. of Racine, Wis., is now serving in the same position with Minneapolis-Moline Co. of Minneapolis.

R. C. HEDGLEN is now associated with Goodyear Aircraft Corp. as senior engineer—standards and methods. He is chiefly concerned with the study and analysis of assembly practices to establish standards for work operations, coordination of tooling and equipment requirements, and reducing manufacturing costs.

Hedglen had been production staff assistant with Kansas City Aircraft Plant of Ford Motor Co.

He has served as SAE Kansas City Section Publicity Committee chairman during 1955.

CONTINUED ON PAGE 105

Obituaries

RALPH S. DAMON

Ralph S. Damon, member of SAE since 1937, died Jan. 4 of pneumonia. He was president of Trans World Airlines and one of the nation's aviation leaders for more than 25 years.

Damon became president of TWA in 1949. He had previously served as president of American Airlines, Republic Aviation Corp., and Curtiss Aeroplane and Motor Corp.

He was born in Franklin, N. H. in 1897 and attended Harvard College, from which he graduated magna cum laude in 1918. He was an Army Air Corps cadet in World War I.

Joining Curtiss in 1922, he became factory superintendent at the age of 25 and president in 1935 at the age of 38.

Damon was very active in technical organizations. He was a member by Presidential appointment of the National Advisory Committee for Aeronautics. He was a member of the Institute of Aeronautical Sciences, the Aviation Advisory Committee of the Harvard School of Business Administration, the National Safety Council, and the American Society of Mechanical Engineers. ASME awarded him the Spirit of St. Louis Medal for his service in aviation.

He was chairman of the board of trustees of Clarkson College of Technology at Potsdam, N. Y. He was also a member of the Overseers Visiting Committee for the Department of Astrology at Harvard College Observatory. For his interest in assistance to Greece he had been made an honorary citizen of Athens.

HAROLD D. DUPPSTADT

Harold D. Duppstadt, chief automotive truck engineer, Aberdeen Proving Ground, died Nov. 4.

He was born in August, 1909 at Athens, Ohio. After graduation from High School, he attended Virginia Military Institute for two years. He then attended Case Institute of Technology and following graduation joined White Motor Co., He served as automotive expert with that company from 1936–1941. From 1941–1942 he was experimental engineer with the Quartermaster Corps at Holabird. From 1942–1943 he was chief engineer in charge of military transport vehicles at Camp Seebly, Calif.

Duppstadt joined Aberdeen Proving Ground in 1943 as chief automotive truck engineer with the Ordnance Corps in the Development and Proof Services Division.

He was one of the country's top specialists in automotive engineering with the U. S. Government. He was also a member of the Ordnance Association.

GLENN L. MARTIN

Glenn L. Martin, founder and director of Glenn L. Martin Co., Baltimore, Md., died Dec. 4. He had retired from active leadership of the company in 1953.

Martin started his career in the automotive business in Santa Ana, Calif. In 1909 he opened his first airplane factory and became fascinated with flying boats. This fascination led to the building of the famous Martin Clipper ships.

In 1917 he merged his firm with Curtiss-Wright to form the Wright-Martin Aircraft Corp., serving as vice-president in charge of aircraft production. As soon as World War I ended, he resigned from the corporation and went to Cleveland to again organize his own firm.

The expansion of this firm set many records for Glenn L. Martin. He built the first multi-passenger airplane; the first twin-engined bomber; the first all-metal seaplane; the first air-cooled engine bomber; the first large plane for an aircraft carrier; and the first practical dive-bomber.

SECTIONS

FEBRUARY 1956

Requirements Revised For New SAE Sections & Groups

An increase in the minimum requirements for new Sections and Groups has been approved by the SAE Council. Purpose of the more stringent requirements is to insure continuance of a high level of technical quality and competence among local units under changing future conditions.

From now on there must be 100 instead of 75 members already living in the territory proposed for the Section . . . and at least 60% of these must hold either "Member" or "Junior" grade of membership. (Under the old requirement 20 of the required 75 or more members had to be of "Member" grade.)

Requirements for a new Group have been upped in somewhat similar proportions. In the future, a minimum of 50 members (with a potential of at least 100) must exist within the territory proposed for the new Group . . . and 60% of the 50 must hold "Member" or "Junior" grade of membership. (Before only 30 members had already to be in the proposed territory . . . and 10 of them had to be of "Member" grade.)

Action by the Council was based upon recommendations of the Sections Committee Executive Committee which had been studying current practices in relation to future needs for more than a year.

WASHINGTON

C. J. Calvin, Field Editor

A special feature of the Section Dec. 14 meeting was the presentation of SAE long-time membership certificates.

Frederick C. Horner, consulting engineer, Army & Navy Club, Wash., received a certificate for 35 years of membership.

Fred H. Purdy, Department of the Navy, Bureau of Aeronautics, Shore Establishments Division, Wash., was presented a 25-year certificate.

Mid-Michigan

G. W. Colby, Field Editor

Double-Duty Doings of 'Meetings and Arrangements'

—R. J. Schultz

Mid-Michigan Meetings and Arrangements Committee members find that their duties fall into two general classifications: advanced preparation and final preparation. The first group of duties must be completed at least five weeks before the meeting. The second group are not completed until the meeting is over.

In our Section, this committee is responsible for providing a meeting place, making arrangements for dinner, making available equipment required by the speaker, providing for entertainment, and acting as a reception committee at the meeting.

Advanced Preparation

The early fall meeting of the Governing Board starts the ball rolling for the coming SAE season. At that time the Meetings and Arrangements Chairman assumes responsibility for the approaching meetings.

The chairman calls a meeting of his committee well in advance of the first Section meeting to familiarize his group with their responsibilities. We have found it advisable to delegate the responsibilities of a given meeting to one specific committee member. In that way he becomes the Arrangements chairman for his specified meeting. The general chairman then acts as consultant and actively assists each of the Arrangements chairmen. The other members of the committee are made available for assistance.

At this special committee meeting, such items as the procedure for arranging meetings, the finances available, and the need to keep the meetings on a high social as well as technical plane are also discussed.

During the advanced preparations, the Arrangements chairman must establish the meeting place, the cost of the dinner, and the entertainment to be provided, if any. Such information must be passed on to the Advertising, Ticket, and Program Committees in sufficient time to allow the dinner meeting anouncements to be prepared and mailed.

Final Preparation

The final preparations occur during the week preceding the meeting. By this time, the Arrangements chairman must have in his possession written confirmations of the meeting and dinner costs. He should also reconfirm all arrangements personally, to be sure that all parties concerned are aware of the approaching meeting.

These final preparations include arrangements for a short social period preceding the meeting. One of the valuable opportunities in being an active SAE member is the development of lasting friendships with associates in the technical field. Therefore, during the social period and the meeting itself, the Meetings and Arrangements Committee has been functioning also

CONTINUED ON PAGE 98

From Section Cameras

as a reception committee. We feel now that it has become necessary to organize a special committee for that duty.

The new Reception Committee will consist of past Section chairmen, who will in all respects be better qualified. They will acquaint new and old members and endeavor to make all members and visitors feel more at ease and welcome.

The last duty of the Committee chairman is to prepare a report of the activities and problems concerning his group during his tenure of office. This will prepare a clear path for the incoming chairman.

ST. LOUIS

F. H. Roever, Field Editor

Parks College of Aernonautical Technology Student Branch members are already planning their contributions to the St. Louis Section Student Meeting in the Spring. They are now busy preparing papers for the annual Student Technical Paper Competition with **Missouri School of Mining & Metallurgy Student Branch.**

1. In the spotlight during Mohawk-Hudson Section Dec. 5 meeting were (left to right) Section Chairman **Hans Schwarz,** 1955 SAE President **Dr. C. G. A. Rosen,** and Admiral W. D. Leggett, U.S.N. (ret.), vice-president of engineering, Alco Products, Inc., Schenectady. Admiral Leggett introduced Dr. Rosen as guest speaker for the evening.

2. **William B. Barnes** (left), Barnes Motor Developments Co., accepts his 35-year Membership Certificate from Indiana Section Chairman **Carson O. Donley.** The presentation was held at the Section Dec. 15 meeting.

3. So. New England Section Chairman **Robert E. Johansson** (center) shares a pleasant moment with meeting dignitaries. At the left is the speaker for the evening, **Sidney E. Miller,** vice-president, Engineering, American Bosch Division, American Bosch Arma Corp. At the right is **John G. Perrin,** consultant in Springfield, Mass., who received a 50-year Membership Certificate.

No. California

L. J. Abell, Field Editor

No. California Section

South Bay Division

New SAE Club at San Jose State College

—Robert H. Dench

An SAE Student Club has been formed at San Jose State College with the promise of being a very active organization on campus. The club boasts an initial membership of better than twenty, with many more interested candidates from both the Aeronautical and Engineering departments.

The club is very appreciative of the help rendered by the South Bay Division of the SAE Northern California Section and especially that of Forest W. Fingerle and C. J. Szukalaski,

From Section Cameras

1. Special guest of Williamsport Section on Dec. 8 was 1955 SAE President **Dr. C. G. A. Rosen** (center). With him are **Dr. Paul Schweitzer** (left), Schweitzer & Hussmann Engineering Office; and **F. G. Rohm** (right), Lycoming Division, Avco Mfg. Corp.

2. Texas Gulf Coast members flocked to Dow Chemical Co., Freeport, Texas, for a tour of plant operations. The tour was followed by dinner on the plant pavilion.

3. Detroit Junior Group members enjoyed a discussion on "Car Performance Today and Tomorrow" by the panel at right. **D. A. Jones** (right), Research Laboratories Division, GMC, served as moderator. Left to right are **P. H. Pretz**, Vehicles Testing Office, Ford Motor Co.; **E. L. Nash**, Studebaker-Packard Corp.; **D. F. Caris**, Automotive Engines Department, Research Laboratories Division, GMC; **Arnold Seligson**, Special Tests Unit, Ford Motor Co.; **F. R. McFarland**, Studebaker-Packard Corp.; and **R. M. Sinclair**, Chrysler Corp.

who have both donated considerable time and effort in the organization of the club.

The present SAE advisor is C. J. Szukalaski, a design engineer at Owens-Corning Fiberglas Corp. The Faculty Advisor is John Bailey, a Rensselaer Polytechnic Institute graduate. The present student chairman is Robert H. Dench, a senior engineering student.

The two outstanding field trips of the club so far have been one through the Ford Motors new Assembly Plant in Milpitas and the other through the Ames Aeronautical Laboratory at Moffett Field. Several business meetings along with educational movies have also been included on the agenda.

The Student Club anticipates a very active year in 1956 with many interesting tours, speakers, and movies.

ATLANTA

G. F. Jackson, Field Editor

General Motors Training Center was opened to Atlanta Section members on Jan. 9 for a tour of the facilities. Members and guests of SAE were deeply impressed by the training facilities provided for the GM Divisions. 90 members took advantage of this excellent opportunity.

So. California

W. E. Achor, Field Editor

How We Decided When and What for Meetings

Section members—566 of them—expressed their preferences regarding meeting nights, meeting places, and subjects to the So. California Governing Board. They were provided questionnaire postal cards.

At one of the early Governing Board meetings, a discussion came up concerning meeting nights and activity interests. It was decided that Section members should have the opportunity to express their opinions.

When

Regarding meeting nights, 472 members okayed the Monday night meetings started last year. This number represents 83% of the Section mem-

Section

ALBERTA

February 17 . . . Al San Club

ATLANTA

March 5 . . . J. F. Socolofsky, supervisor, Lubricants Section, Socony Mobil Oil Co., Inc., Research & Development Department, Paulsboro, N. J.—"Combustion Chamber Deposits—Influence of Fuels & Lubricants." Briarcliff Hotel. Dinner 7:00 p.m. Meeting 8:15 p.m.

BUFFALO

February 29 . . . John Van Lonkhuyzen, chief of Technical Department, Bell Aircraft Corp., Niagara Falls, N. Y.—"Satellites, Rockets and Guided Missiles." Hotel Sheraton. Dinner 7:00 p.m. Meeting 8:00 p.m.

CANADIAN

February 15 . . . Robert Jackson, Perfect Circle Co., Ltd. Royal York Hotel, Toronto. Dinner 6:30 p.m.

CENTRAL ILLINOIS

February 27 . . . J. D. Loftis, assistant general superintendent—motive power, Rock Island R. R. Co.—"The Jet Rocket Train." Pere Marquette Hotel. Dinner 6:30 p.m. Meeting 7:45 p.m.

CHICAGO

February 14 . . . W. E. Swenson, assistant director of engineering, Minneapolis-Moline Co., Minneapolis, Minn.—"Minneapolis-Moline's Approach to a New Tractor Program." Knickerbocker Hotel, Chicago. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Features: Social Half-Hour sponsored by Federal-Mogul Corp., and Rockford Clutch Division—Borg-Warner Corp.

CLEVELAND

February 13 . . . Victor G. Raviolo, director, Advanced Product Study and Engineering Research Office, Ford Motor Co., Engineering Division, Dearborn.—"Automotive Safety." Hotel Manger. Dinner 6:30 p.m. Meeting 7:45 p.m. Special Features: Ladies Night.

COLORADO

February 16 . . . Paul E. Waggoner, manager, Truck Repair Shop, Safeway Stores, Denver, Colo.—"Tour of Facilities." Safeway Stores, E. 46th & Colorado Blvd. Meeting 8:00 p.m.

DETROIT

February 20 . . . L. G. Boehner, chief engineer, Volkswagonwerk, Germany.—"Light Trucks and Buses in Europe." Rackham Educational Memorial. Dinner 6:30 p.m. Meeting 8:00 p.m. Special Features: Dinner Speaker: **Nils Hammarskjold, Jr.** Subject: "Taxation and Technology"

INDIANA

February 16 . . . U. M. Staebler, chief, Civilian Power Reactors Branch, Atomic Energy Commission.—"Peaceful Applications of Nuclear Energy." Marott Hotel, Indianapolis. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Features: Social Half-Hour 6:30 p.m.

KANSAS CITY

March 5 . . . Albert B. Lillie, Federal Mogul Bearing Co.,—"Bearings and Application (Sliding Surface Bearings)."

METROPOLITAN

March 1 . . . F. G. Dougherty, product engineer and **M. C. Hardin,** Allison Division, GMC.—"Fuel and Lubricant Requirements of Commercial Aircraft Turbine Engines." The Brass Rail Restaurant, Fifth Avenue & 43rd Street, New York. Cocktail Hour 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.

Meetings

MILWAUKEE

March 2 . . . Dr. Donald Nelson Frey, associate director, Scientific Lab., Ford Motor Co., Dearborn. —"Design Consideration for the Two Shaft Automotive Turbines." Milwaukee Athletic Club. Dinner 6:30 p.m. Meeting 8:00 p.m.

MONTREAL

February 20 . . . Subject and Speaker to be announced.

NEW ENGLAND

March 6

NORTHERN CALIFORNIA

February 29 . . . Student Meeting. Stanford University. Special Features: Dinner on Campus and Tour of Facilities.

NORTHWEST

March 9 . . . W. E. Thill, assistant chief engineer, Federal-Mogul Corp., Detroit.—"Engine Bearings, Their Design and Maintenance." Stewart Hotel, Seattle, Wash. Dinner 7:00 p.m. Meeting 7:45 p.m.

ST. LOUIS

March 19 . . . Student Night at Parks College. Technical papers presented by students from Parks College of St. Louis University and Missouri School of Mines & Metallurgy.

SAN DIEGO

March 6

SOUTHERN CALIFORNIA

February 13 . . . Earl R. Kline, assistant chief engineer, Continental Aviation & Engineering Engineering Corp., Detroit, Mich. —"Whisper Engine." Rodger Young Auditorium. Dinner 6:30 p.m. Meeting 8:00 p.m.

SOUTHERN CALIFORNIA

February 27, 28, 29 . . . Fuels & Lubricants Seminar. General Petroleum Auditorium, Los Angeles, Calif. **F. A. Christiansen,** Seminar Chairman.

Feb. 27 . . . "Passenger Car Fuel Injection System." **P. Kyropolous,** associate professor of mechanical engineering, California Institute of Technology; and **J. Brent Malin,** manager, Western Regional Laboratory, E. I. du Pont De Nemours & Co., Inc., Los Angeles.

Feb. 28 . . . "Fuels for Commercial Jet Transports." **Karl A. Weise,** chief of Power Plant Section, Douglas Aircraft Co., Santa Monica, Calif.; **John B. Pitkin,** power plant and safety engineer, Lockheed Aircraft Corp., Burbank, Calif.; and **J. A. Bert,** senior research engineer, Aviation Products, California Research Corp., Richmond, Calif.

Feb. 29 . . . "Latest Developments in Liquefied Petroleum Gas-fueled—Industrial and Commercial Mobile Equipment." **K. W. Coghill,** general foreman, Transportation, Douglas Aircraft Co., Santa Monica, Calif.; **F. E. Pilling,** vice-president in charge of production, Century Gas Equipment Co., Lynwood, Calif.; and **Max Ellis,** manager, Ellis Manifold Co., Los Angeles, Calif.

SOUTHERN NEW ENGLAND

March 7 . . . James H. Moore, general manager, Vacuum Metals Corp., Syracuse, N. Y.—"Vacuum Melted Steels for Bearing Applications." Rockledge Country Club, West Hartford, Conn. Dinner 6:45 p.m. Meeting 8:00 p.m.

TEXAS

March 9 . . . Fuels and Lubricants

TWIN CITY

March 14 . . . E. Fomento, district engineer, Electromotive Division. GMC, La Grange, Ill.—"History and Development of GM Locomotive Engine." Napleon's Restaurant, Midway, St. Paul, Minn. Dinner 6:45 p.m. Meeting 8:00 p.m.

bers. Other preferences were divided among Tuesday, Wednesday, and Thursday.

What

Members were then asked to note which activity they were primarily interested in. The results are tabulated as follows:

1.	Aeronautical	275
2.	Aircraft Production	160
3.	Fuels & Lubricants	92
4.	Transportation & Maintenance	92
5.	Passenger Car	86
6.	Truck & Bus	78
7.	Diesel Engines	69
8.	Automotive Production	33

It was expected that the major interest in So. California would be aircraft, since most of the basic engineering of engines, trucks, and buses is done in the eastern part of the country. The interests shown verified the agenda which calls for two aircraft dinner meetings, an aircraft panel meeting, and a three-day technical seminar on aircraft problems.

An example of the last is the recent seminar on "Environmental Testing Aircraft & Missiles." The other activity meetings are held on a level for greater general interest or of specific interest to more than one activity. The panel meeting on "Valve Problems" which reached the interest of 5 basic activities is an example of the second.

BUFFALO

Dudley Losee, Field Editor

Why Ladies' Night Is an Annual Success

Detailed planning for an annual Ladies' Night is enthusiastically pursued from the first Board Meeting until its occurence at the December Section meeting. Buffalo Section engineers enjoy planning and presenting this social function to the mutual enjoyment of both engineers and their wives.

Each year the Program Committee attempts to plan a program of greater interest to the women, yet more informative to the men, than the year before.

After the stage is set, the Publicity, Reception, and Ticket Sales Committees prepare for a busy evening.

This year the Program Committee decided upon the subject of man-made gem stones for the Dec. 13 meeting. Dr. Thomas F. Hart of the Silicone De-

partment of Linde Air Products Co. discussed the decorative and aesthetic use as well as the commercial and industrial value of man-made gems. He illustrated his talk with a display of synthetic gems, including a reproduction of Queen Elizabeth's Coronation necklace and earrings.

Mrs. Robert R. Falconer examines a formidable bow-knot on her prize package. Standing behind her is **A. H. Gille**, Buffalo Section vice-chairman. To her left are Mrs. and Mr. **Dudley Losee**. The event is Ladies' Night, Dec. 13.

The Reception Committee greeted each lady with a favor during the social period when the wives became acquainted with their husbands' professional associates. Members especially enjoyed watching the ladies who had won prizes struggle to open their packages, which had been decoratively, but very securely, wrapped.

The smiles that spread around the hall were proof that Buffalo Section would enjoy many more successful Ladies' Nights.

So. New England

S. L. Leavitt, Field Editor

John G. Perrin (see page 98), Springfield, Mass. consultant, has been a member of SAE for 50 years. He was presented a 50-year certificate at the Southern New England Section Dec. 6 meeting.

Certificates for 35 years of membership were presented to **John R. Aude**, retired; **Alexander H. King**, Pratt & Whitney Aircraft Division, United Aircraft Corp.; and **George M. Williams**, Russell Mfg. Co.

Four other members received 25-year membership certificates. They are **Roger H. Casler**, Roy S. Sanford & Co.; **Albert W. Hagan**, Wolverine Motor Works, Inc.; **Hans Hogeman**, American Bosch Division, American Bosch Arma Corp.; and **Foster N. Perry**, American Bosch Division, American Bosch Arma Corp.

Texas Gulf Coast

—L. F. Mock, Jr.

Dow Chemical Co., Freeport, Texas, opened its doors to inspection by members and guests of Texas Gulf Coast Section for the November meeting.

The group of 160, including approximately 25 SAE enrolled students from Texas A & M College, met at the main building and were first shown a film of the chemical plant operations. They were then taken on a bus tour of the entire plant, with guides to explain the most interesting parts of the manufacturing facilities.

MONTREAL

A. A. Larkin, Field Editor

Stimulating Section Student Branch Activities

—E. D. Gray-Donald

Encouraging student activity is a constant duty for an SAE Section Governing Board. The student body is one valuable source from which the Section will derive quality members. These young members will, in turn, derive many advantages from their membership in SAE.

Stirring Student Action

Montreal Section stimulates student interest by:

1. Sponsoring student technical paper competitions.
2. Arranging a special dinner-meeting price for students.

The first method is by far the most successful. Students welcome the opportunity to compete in their technical fields. Papers written for an SAE competition can often prove valuable in the student's course of study.

Montreal has two universities—one French speaking and one English speaking. Through the Engineering faculties of the two schools, Montreal Section invites one student from each University to present a paper before the Section. Cash awards are given to the two students participating, according to merit. In addition, they are given student enrollment in the Society for one year at the expense of the Section.

1953–1954 was our first year in this project and considerable interest was stimulated. The papers were selected by the University Staffs from quite a number that had been prepared chiefly as summer work. We arranged for a panel of judges to appraise the two papers that were presented.

1956 Plans

This year one of the Universities is arranging for a candidate of its own selection to deliver a paper. The other has presented us with five papers from which they have asked us to make a choice. It will be interesting to see what results are obtained.

On our Students' Night this year, we are also having a short talk on the engineering profession by a member of the Governing Board.

We intend to make the student paper competition an annual event. We believe that this project is the most effective and satisfying for stimulating student activities.

INDIANA

V. L. Alexander, Field Editor

William B. Barnes was presented a 35-year membership certificate at the Dec. 15 meeting of Indiana Section. Barnes is the owner of Barnes Motor Development Co. of Muncie, Ind.

Adolph G. Schneider, vice-president and general manager of Schneider Mfg. Corp. received a 25-year certificate. Schneider Mfg. Corp. is also in Muncie.

Section Chairman **Carlson O. Donley** made the presentations.

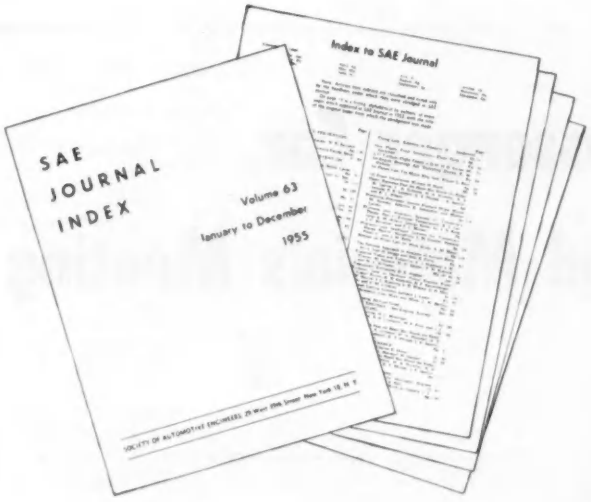
CINCINNATI

H. E. Pitzer, Field Editor

University of Cincinnati Student Branch officers included two plant tours in their agenda for meetings this spring.

Jan. 20 brought an inspection trip through the Cincinnati Ford Transmission plant. Feb. 10 will bring a tour of the General Electric plant.

Further plans include a second annual Economy Run and a Student Paper Competition. Literature explaining the techncial paper requirements and rules for qualification have been distributed.



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AN INDEX of all technical articles published in the 1955 issues of the **SAE Journal** will be ready about March 1.

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SAE Journal sooner or later prints an abridgment of every paper presented at SAE National and Section Meetings. So, every paper is mentioned at some time in the INDEX.

Every paper is indexed by:

1. ***Original title.***
2. ***Journal headline.***
3. ***Authors' names.***
4. ***Subject headings.***

When the **Journal** article contains discussion, the names of the discussers are also listed.

The 1955 INDEX covers all material published in the **Journal** during 1955, based on the following:

1. ***Papers presented at National Meetings.***
2. ***Papers presented at Section Meetings, received at SAE Headquarters.***
3. ***Round table and production panel reports received at SAE Headquarters.***

SAE National Passenger Car, Body, and Materials Meeting

Puts the Spotlight on . . .

Body Trim Materials

Passenger Car Noise Problems

New Passenger Car Brake Developments

Developments in Automatic Transmission Materials

Hotel Statler **March 6-8, 1956** **Detroit, Michigan**

1956 SAE National Meetings . . .

March 6-8
Passenger Car, Body, and Materials Meeting
Hotel Statler
Detroit, Mich.

March 19-21
Production Meeting and Forum
Hotel Statler, Cleveland, Ohio

April 9-12
Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display
Hotel Statler, New York, N. Y.

June 3-8
Summer Meeting
Chalfonte-Haddon Hall
Atlantic City, N. J.

August 6-8
West Coast Meeting
Mark Hopkins Hotel,
San Francisco, Calif.

September 10-13
Tractor Meeting and Production Forum
Hotel Schroeder, Milwaukee, Wis.

October 2-6
Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display
Hotel Statler, Los Angeles, Calif.

November 1-2
Diesel Engine
The Drake, Chicago, Ill.

November 8-9
Fuels and Lubricants Meeting
The Mayo, Tulsa, Okla.

About SAE Members

Continued from page 96

ANDREW J. SUTTON has joined Brunson Instrument Co., Kansas City, Miss., as field engineer. He has been quality control representative for Aircraft Engine Division of Ford Motor Co.

His new position entails field engineering prior to and after installation of Brunson optical tooling for industry.

CHARLES C. COZZENS is now associated with Resistoflex Corp., Dallas, Texas as a sales engineer. He represents the company in Texas and Oklahoma.

Formerly Cozzens served with Air Associates, Inc in the same capacity.

GEORGE E. BILLMAN is now with General Electric Co.'s Gas Turbine Division, Jet Engine Department in Evendale, Ohio. He had been located with Convair Division, General Dynamics Corp. as a test engineer.

THOMAS COUPER has become general vice-president of L. A. Young Spring & Wire Corp., Detroit. He has been vice-president, sales and advertising.

PETER J. GALLETTE has been named vice-president, automotive sales, by Young Spring & Wire. He has been serving as general sales manager since 1951.

FRANK L. RAGGI, previously service engineer for Oliver Corp., Cleveland, has become industrial service representative for the corporation in Chicago.

CLIFFORD A. FORDHAM has joined M. C. Manufacturing Co. as a design engineer. He was a design engineer, Automotive Section, Aluminum Co. of America.

GEORGE B. MOSELEY has been appointed vice-president in charge of sales for Chase Brass & Copper Co., Inc., a subsidiary of Kennecott Copper Corp. For the past seven years he has been general sales manager for Firestone Steel Products Co., Akron, Ohio.

AARON VANGLISH has joined Hamilton Standard Division, United Aircraft Corp., Windsor Locks, Conn., as a design engineer. He was a project engineer with Parkchester Machine Corp. of New York City.

His work with Hamilton Standard Division involves the design of component parts of jet fuel controls.

E. S. BURDICK has been appointed by the Cold Metal Products Co. of California to fill the newly created position of service engineer. He was with the Crucible Steel Company of America, Los Angeles sales department.

FREDERICK A. WINZER, JR. has been appointed general sales manager of Weatherhead Co., Aviation Division in Antwerp, Ohio. He has been assistant to the general sales manager of Curtiss-Wright Corp. Propeller Division.

DONALD R. DREAS has joined Rohr Aircraft Corp. as a tool engineer. He has been a project engineer with A. O. Smith Corp.

PHILIP A. PLANO is now serving as mechanical consultant on electronic developments as section engineer for Philco Corp.'s Government and Industrial Division, Philadelphia, Pa. He has been associated with O. E. Szekely & Associates, Inc. as vice-president in charge of engineering.

CONTINUED ON PAGE 106

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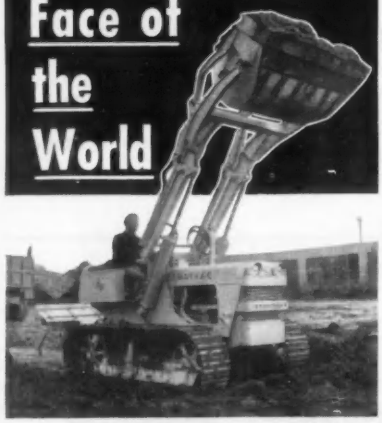

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Wherever you go, these days, you see men at work re-shaping the landscape with the aid of specialized machines. And no matter what the specific job—clearing land, ditching for irrigation, grading for highways, laying pavement or erecting buildings—you'll note a pronounced swing to equipment with Continental power. . . . The adoption of dependable Red Seals—gasoline or Cushioned Power Diesel—by more and more leading builders of specialized machines, reflects a spreading recognition, on the part of machine *users*, of this basic fact: There's a vast difference, in performance, dependability, economy and upkeep cost, between the ordinary engine and the Continental that's engineered and built for its job.

•

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MUSKEGON AND DETROIT

About SAE Members

Continued from page 105

SYDNEY E. LEESE is now chief engineer for Houdaille Industries, Inc., Buffalo. He was a project engineer for Bendix Aviation Corp. in the Detroit research laboratory.

In his new position Leese has responsibilities of product engineering for automotive products such as: shock absorbers, automatic transmission pumps, viscous torsional vibration dampers, and automobile seat actuators.

ROBERT M. LYNAS has been appointed assistant division industrial engineer for Michigan Division of Thompson Products, Inc. He has been an industrial engineer with the company.

E. A. NIDA is now production manager at the Mahwah Assembly Plant of Ford Motor Co. Ford Division. He had served in the Ford Kansas City Aircraft Plant as superintendent of wing structure assembly operations.

ROBERT R. LANGE has joined Ford Motor Co. as a project engineer. He has served as engineer for Electric Auto-Lite Co.

B. BYRON LeMAY, JR. is now transmission project engineer for Oliver Corp., South Bend, Ind. He has been project engineer for Westinghouse Electric Corp., Hydraulic Drives Division, Muncie, Ind.

RANDALL GOFF, previously a mechanical engineer with the National Bureau of Standards in Washington, D. C., is now serving in the same position with Special Purpose Engine Co. of Norwalk, Conn.

FRANCIS A. SCIABICA has joined Ford Motor Co. as a product design engineer, Advanced Engine Department. He has been a test engineer for Continental Aviation & Engineering Corp.

WILLIS M. CLARK, JR. is now associated with Ford Motor Co. as product engineering designer specializing in mechanical arrangements for gas turbines. He had been senior layout draftsman for Studebaker-Packard Corp.

CONTINUED ON PAGE 107

SINCE 1907

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About SAE Members

Continued from page 106

WILLIAM WINN, JR. is now resident engineer with Chrysler Corp. Gear & Axle Plant, Detroit. He had been plant metallurgist.

HERBERT CLARK, formerly managing director of Clifford Aero & Auto, Ltd. of Birmingham, England, has joined J. A. Prestwich & Co., Ltd., London as director in charge of manufacturing.

DR. JOHN ARTHUR CARLSON has joined Armour Research Foundation of Illinois Institute of Technology as a research engineer.

ALLAN A. HARRIS has become general manager of McCulloch Equipment Co., subsidiary of McCulloch Motors Corp. He has been manager—lawnmower sales.

LUCIANO F. MOLINARI is now associated with North American Aviation, Inc. of International Airport, Los Angeles, as design engineer. He had served in the same position with Sikorsky Aircraft Division of United Aircraft Corp.

His new position will entail design of components necessary for the installation of jet engines in the airframe.

LEONARD H. GERIN has taken a position with Yates-American Machine Co. of Beloit, Wis, as sales engineer. He was a design engineer with Barrett-Cravens Co., Northbrook, Ill.

JOE H. TALLEY is now chief engineer of Frye Corp., Fort Worth, Texas. He is concerned with the manufacture of commercial transport aircraft.

He has been with Chance Vought Aircraft, Inc. as a project design engineer.

JOHN R. MORROW has joined Casco Products, Inc. as Detroit sales representative. He was associated with Kaydon Engineering Corp. as assistant sales manager.

HARRY PAUL DOBROW is now with Westinghouse Electric Co., Atomic Power Division, Pittsburgh. He is serving as advisory engineer, Advance Planning & Development.

Dobrow has been assistant to the vice-president, Operations, for Alloy Engineering & Casting Co., Champaign, Ill. He has been in engineering product development programs for 20 years.

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Aluminum Roofs Will Help Car Styling

Based on paper by

DAVID P. REYNOLDS
Reynolds Metals Co.

AUTOMOTIVE use of aluminum has climbed from a postwar low of 6 to 18 lb per car to an average of 35 lb. There are some 65 lb of aluminum in the Plymouth. Nash uses the metal for window frames. The Cadillac El-Dorado contains 192 lb. These 192 lb replace 400 lb or more of steel. If you lump together all the aluminum items used in the automobile, but not all in one car, you find the total poundage to have risen from 62 to 275 in five years.

Use of aluminum for car roofs seems to be definitely on the way. Brushed aluminum has been used already for the roofs of some special cars. The appearance is pleasing, the metal is fade-proof and easily cleaned. Being an efficient solar reflector, aluminum could contribute to summer comfort and to lightening the load on air conditioning systems.

Aluminum may soon be used for hood, outer deck, and door panels, and for electrical harness. (Paper "Aluminum in Automobiles" was presented at SAE Detroit Section, November 7, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

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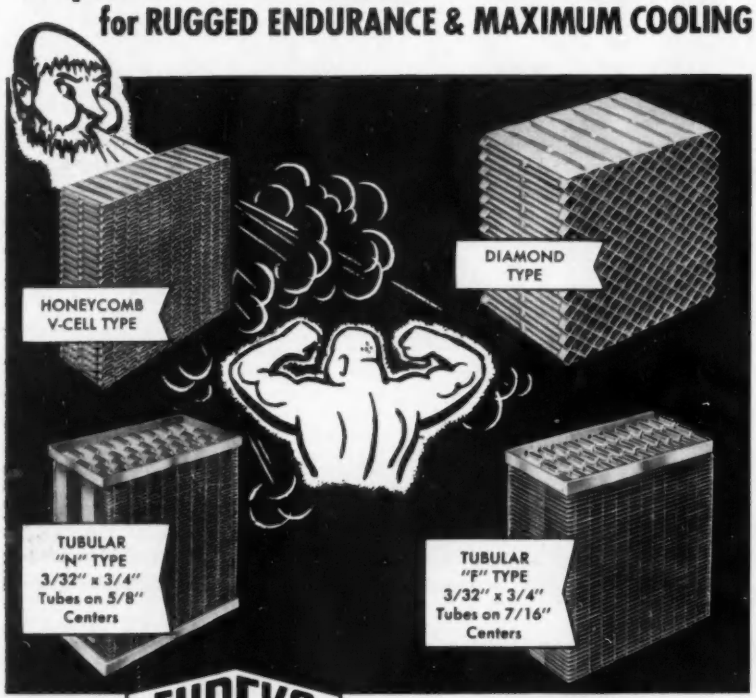

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Molded Nylon Used For Gears and Bearings

Based on paper by

JOHN D. YOUNG
E. I. du Pont de Nemours & Co., Inc.

THE mechanical properties of molded nylon are providing satisfactory gears which need not have the close dimensional tolerances that metal gears must have to reduce vibration and noise. And by the same token, slight inaccuracies of tooth form and spacing are less important because of the material's resiliency.

First consideration in the design of molded nylon gears is power transmitted. Preliminary tests have established that the safe working stress factor in the Lewis gear formula varies from 1700 to 4500 psi as the pitch line velocity is reduced from 4000 to 100 fpm.

The molded nylon resin (which du Pont manufactures under the tradename Zytel) has been used to produce a one-piece speedometer take-off gear and shaft; also the speedometer driving gear, speedometer driven pinion, and an adapter, shown in Fig. 1.

Resistance to abrasive wear and low coefficient of dynamic friction are the

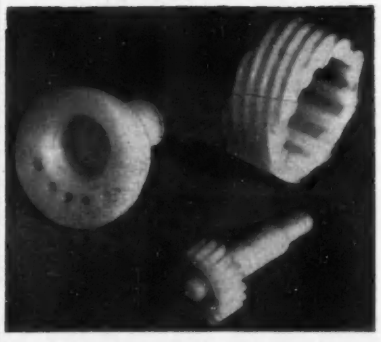

Fig. 1—Speedometer driving gear, speedometer driven pinion, and adapter made of molded nylon. Gears used in this train showed no wear after 48,000 miles of road test.

properties recommending this material for bearings. In many applications the bearings require no lubrication, although use of conventional lubricants will give improved performance. Upper limits of loads and speeds can be extended by providing for the dissipation of frictional heat, either by the use of ample lubrication or by the design of the bearing and mounting. Exceptionally long service life may be expected where temperatures of the contact surfaces are stabilized well below the heat distortion point. Surface temperatures up to 250 F are considered satisfactory. Temperatures above 300 F have been withstood where loading has not been excessive. Temperature of the bearing surface may be kept to a minimum by the use of thin wall sections.

As an example of heavy-duty application may be mentioned the 8 main hanger bushings and 16 shackle bushings in one torsion bar tandum axle trailer (Fig. 2).

The entire trailer load is carried on these bushings, which have been designed so that the unit loading is kept within the material limitations of nylon. In this instance, loads may reach 1800 to 2000 psi. In the design of the main hanger bushing a threaded section has been used to give a greater load bearing area. The section also serves as a thrust bearing surface. It is understood that the bushing previously used required replacement every 25,000 to 50,000 miles of the trailer's life, whereas some of the nylon bushings have given up to 100,000 miles of service life and the upper limit is not known.

A nylon bushing in a brake camshaft assembly represents another heavy-duty application. The nylon does not rust or corrode and is unaffected by continuous operation to 250 F or in subzero temperatures. The galling and brinelling of the camshaft through neglect of lubrication have been eliminated, while the resiliency of the material keeps the bushing from flattening out after long mileage. (Paper "Automotive Applications for Zytel Nylon Resin" was presented at SAE Golden Anniversary West Coast Meeting, Portland, Ore., Aug. 17, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

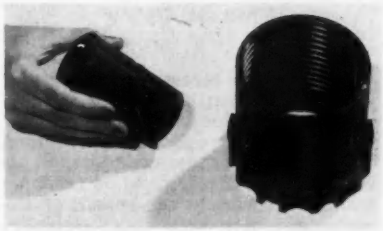

Fig. 2—Torsion bar tandum axle trailer equipped with 8 main hanger bushings and 16 shackle bushings made of nylon, as shown, carries full cross-country load. Some of these bushings already have given 100,000 miles of service life.

Based on Discussion

W. R. Kosy, Chrysler Corp.

Nylon has many fine properties—and also many of the limitations associated with plastic materials. Its linear coefficient of thermal expansion, for example, is eight times that of steel and four times that of aluminum. For some applications, as in the speedometer pinion, this difference can be tolerated. In one instance, however, when a nylon gear several inches in diameter was run inside a metal housing under close tolerance, the gear froze because an increase of 150 F in temperature resulted in a greater expansion of the nylon than the metal.

Moisture absorption is another property of nylon to be considered. Under most circumstances a small percentage of moisture is beneficial to nylon because it improves impact strength. But it causes nylon to swell. A 1-in. diameter nylon bushing designed for a slip fit in a hole may end up as a press fit if exposed to high humidity for a period of time.

Our experience indicates that 24 hr at 300 F under no load can cause considerable embrittlement of nylon.

Truck Silencing Makes Real Progress—But!

Based on paper by

LEWIS C. KIBBEE
American Trucking Associations, Inc.

TRUCK manufacturers have adopted a voluntary standard of 125 sones for truck loudness. This standard has been agreed to by truck operators as being practical and obtainable. Virtually all new trucks coming off assembly lines have mufflers at least as quiet as this standard. Manufacturers of replacement mufflers are tooling up to produce mufflers for older vehicles that will likewise meet the standard.

This represents tangible progress. But administrators now find themselves in a dilemma. The voluntary standard is difficult to measure with portable instrumentation, thus making enforcement a problem when a suspected offender argues that he thinks he meets the standard. If the enforcement officer has no meter to show that the truck noise exceeds the 125-sone standard, he lacks the data on which to base an arrest. If, on the other hand, the administrator adopts the decibel reading as a standard of noise, he finds the enforcement standard has little relationship to the standard adopted by manufacturers and users alike. (Decibels are easy, however, to measure with simple instruments that can be carried in a police car.)

One proffered solution is for truck and replacement muffler manufacturers to certify respectively what vehicles and what mufflers meet the 125-sone standard. A muffler would have to be certified for a specific model of truck,

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Space doesn't permit us to tell you all about him here. Suffice it to say that he's a dedicated soul (he professes no specific creed or faith) who has devoted his life to a study of the "Nature and Application of the Ball" . . . particularly our own DEEP HARDENED and TEMPERED carbon steel bearing balls.

We think you'll want to read the fascinating case histories which he will present in this space in the months ahead. But first, we'd like to send you a more detailed and comprehensive explanation of this little man's background and favorite study subject. So, just drop us a line and we'll send you a formal introduction to . . . *the abbot*.

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but this is thought to be a surmountable task.

Actually, it makes little difference if a truck makes 120 or 130 sones in a loudness test. It can be considered quiet by contrast with the 300 sones that some trucks are making. An officer can tell a 300-sone truck from a 125-sone one without getting out of his car and without instruments. Perhaps there should be a set of instruments at the stationhouse in case a truck owner puts up an argument.

But if enforcement starts by giving tickets to trucks making noise in excess of 200 sones, and forgetting those that have 130-sone mufflers, we'd be a long way down the road towards doing what would please the public and what administrators are trying to achieve. (Paper "A Practical Approach to the Truck Noise Problem" was presented at SAE Golden Anniversary West Coast Meeting, Aug. 15, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Based on Discussion

E. B. Odgen
Consolidated Freightways, Inc.

All we operators want is to be able to purchase a truck with the present 125-sone muffler on it and be able to deal with reputable replacement muffler manufacturers to secure certified replacement products. We believe there is need for four or five places in the nation where the muffler producer can have a muffler certified.

Enforcement officers may need some sort of checking device. If so, commercial equipment is available for setting up in scalehouses or any other place from time to time.

Simplify Maintenance Is the Plea of the Army

Based on paper by

R. C. NAVARIN
and
KARL H. USOW
Corps of Engineers, U. S. Army

THE Army has become a great user of high-production, large-capacity, complex construction machinery. This equipment must be capable of sustained use under all weather conditions in all parts of the world. And it must be maintained without the benefit of experienced personnel. Consequently, the need for easier maintenance is even greater than in private industry.

The way to get this essential simplification is to apply the principles and techniques of easy maintenance in the

basic design of the equipment. Even if this results in slightly higher initial costs, it's not serious because it would be more than compensated for by the reduction in downtime and by less costly repairs. The military is willing to pay to get the long run savings.

During the last war the need for ease of maintenance was so great that the Department of the Army directed the Ordnance Corps to initiate studies. Its success stimulated the Corps of Engineers to investigate its own equipment. Engineer Research and Development Laboratories have conducted studies and found it feasible to apply ease of maintenance principles to commercial construction equipment and have tried with some success to interest industry.

The CIMTC Steering Committee of the SAE established Subcommittee XVI last spring for the sole purpose of investigating ease-of-maintenance practices and principles, and recommending desirable techniques to industry. This committee will form the nucleus for a coordinated activity which includes liaison between the military and industry, evaluation of techniques, and dissemination of the information and data obtained. The Army expects to derive much benefit from this committee. With proper care and handling, ease-of-maintenance practices will someday become "recommended procedure" and will be as commonplace in design criteria as specifying tolerances or screw thread sizes.

One of the most powerful steps the military can take is to include ease-of-maintenance features in their specifications to the end that eventually they will become part of the basic design. Here are some of the concepts already outlined which may appear in future specifications:

1. Good ease of maintenance characteristics can be obtained by emphasizing the following principles during design:

a. All high mortality parts, components, and major assemblies shall be accessible for repair and replacement with minimum removal of other assemblies and components.

b. Preventive maintenance shall be easily performed and so obvious to the operator as to be done almost automatically.

c. Designs shall provide for easy servicing, adjustment, and repair, and shall minimize guesswork by operator, grease-monkey, or mechanic.

d. All connectors shall be standardized and number of sizes held to a minimum. Standard tools shall be adequate for servicing, adjustment, and repair.

2. Features which should be considered for achieving good ease of maintenance are:

a. Lubrication points should be accessible and obviously identified by color to insure day-to-day service.

b. Drain and check plugs should be of the same type and standard size where practicable.

c. There should be reduction in number of bolts and capscrews and use of hinges to speed and simplify removal of covers, guards, and housings.

d. There should be quick release fastenings on mechanical, hydraulic and electrical connections. On fluid lines these connects should have a self-sealing feature to prevent loss of fluid.

e. Power package, including cooling system, engine, and clutch, should be replaceable as a single unit with standardized mountings.

f. Lifting eyes or provisions for them should be provided on all heavy assemblies.

g. Aligning devices such as dowels and guides should be provided to aid

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REX DIVISION
Los Angeles 45, California

in positioning heavy, bulky assemblies.

h. Consideration should be given to proper selection of connectors such as bolts, studs, capscrews, and bolts with spot welded nuts.

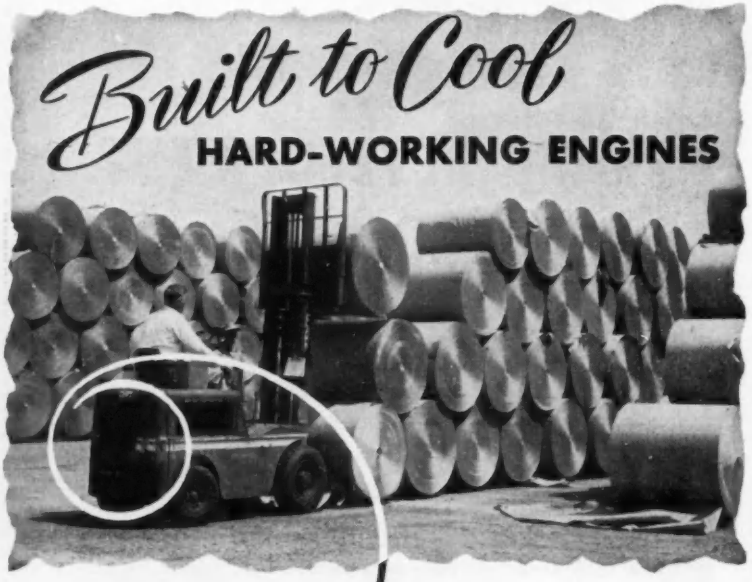
(Paper "Design and Ease of Maintenance" was presented at SAE Golden Anniversary Tractor Meeting Milwaukee, Sept. 13, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Based on Discussion

W. P. Edwards

Contractors' operations are admittedly different from those of the military. Since the larger portion of the construction equipment business is directed to the contractor, it is natural that he be given first consideration.

Emphasis will probably be placed on those features from which the civilian contractor and military will both benefit rather than on those features which will benefit the military, but may or may not aid the contractor.



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Valve Should Protect Against Brake Air Leaks

Excerpts from paper by

HOMER T. SEALE
Homer T. Seale, Inc.

IN designing or selecting the valve for a breakaway system for tractor-trailer brakes, we suggest that you look at it not solely as a breakaway device, but also as a device to protect against low pressure due to any source, including broken lines.

We recommend that the trailer valve limit the flow of pressure from tractor to trailer to an amount less than compressor production, to the end that any spillage beyond the trailer valve would not deplete the tractor pressure more rapidly than the compressor could replace such loss.

We recommend that all pressure delivered to the trailer reservoir be reserved exclusively for trailer use to the end that any spillage forward of the trailer valve shall not deplete the trailer brakes.

(Paper "Air Breakaway Systems for Tractors and Trailers" was presented at SAE Golden Anniversary West Coast Meeting, Portland Ore., Aug. 15, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

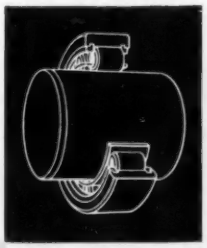
Discussion

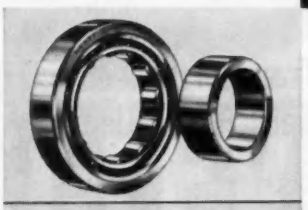
—E. B. OGDEN,
Consolidated Freightways, Inc.

Recently there have been two accidents—one in Liberty, N. Y. in July 1954 and one in San Francisco in May 1955, I believe—involving a runaway tractor or semi-trailer afflicted with failure of air-operated service brakes. A total of 16 people were killed, and I believe several hundred thousand dollars of property damage was done. As a result the Interstate Commerce Commission is extremely disturbed as to the safety of air-operated service brakes. Frankly, I think they have every right to be alarmed.

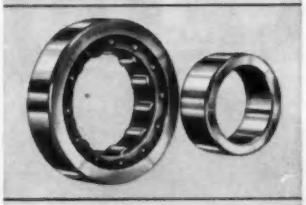
In an effort to avoid repetitions of these accidents the ICC is looking for a means of correction. It is my concern at the moment that in securing counsel from the industry ICC may

4 types with separable inner races

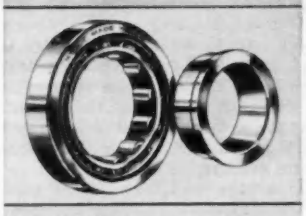




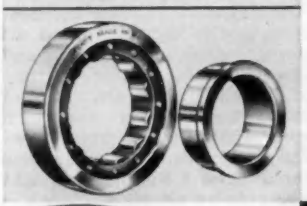
A-TS Single row, straight inner race, rollers retained by cage, end rings or retainment rings recessed in outer race, inner race completely separable.



A-WB Single row, straight inner race, double flanged outer race, inner race completely separable.

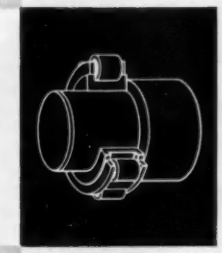


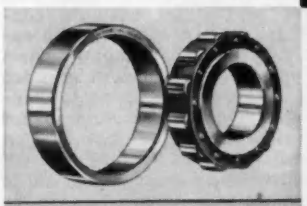
R-YS Single row, single flanged inner and outer races, rollers retained by flange and single retainment ring recessed in outer race, inner race completely separable.



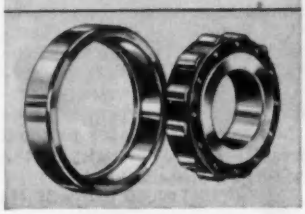
R-WB Single row, double flanged outer race, single flanged inner race, inner race completely separable.

2 types with separable outer races





BU-Z Single row, double flanged inner race, straight outer race, outer race completely separable.



BU-L Single row, double flanged inner race, single flanged outer race, outer race completely separable.

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HYATT
ROLLER BEARINGS

become over-sold on more safety gadgets to the extent that nothing will be gained safety-wise and much will be added to the cost as well as maintenance of the equipment.

I recently saw a proposal by ICC regarding the wording of a new ruling which if adapted would mean practically a brake valve on each axle with a separate operating valve in the cab. With such an arrangement you would have to "play" the brakes like a pipe organ rather than apply them. Let's hope this is never brought to pass.

I would much prefer to see H. T. Seale's recommendations put into practice. His idea affords:

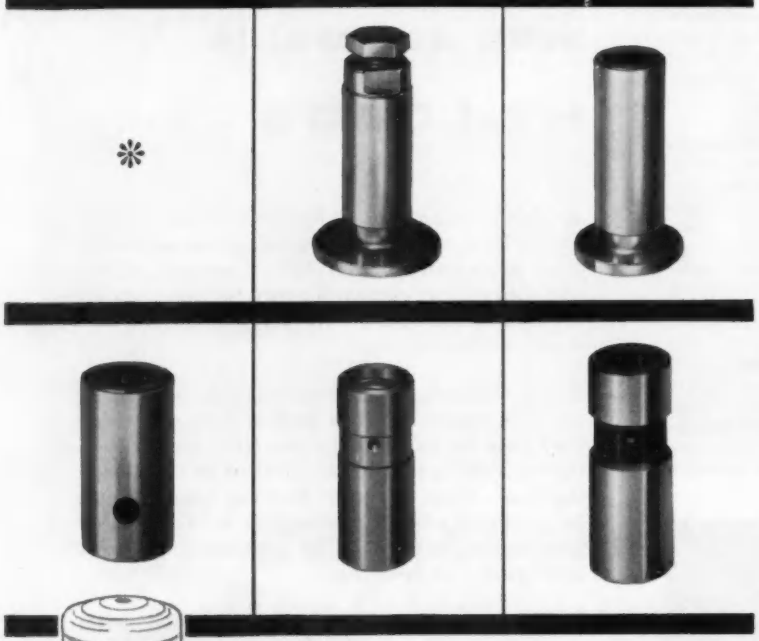
1. Complete trailer brakeaway protection.

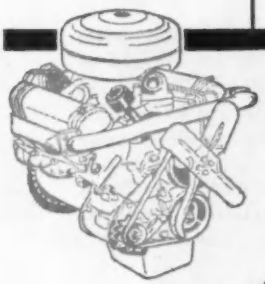
2. With complete loss of air in trailer tank due to blown brake chamber diaphragm, no noticeable loss of air on tractor with engine running at 1500 rpm.

3. A full tank of air for trailer brake application, insured because no air bleeds back from the trailer.

These suggestions can be followed by anyone making air brake equipment with a minimum of cost. With these safeguards, plus the tractor protector valve, we have about the ultimate in safety and simplicity.

JOHNSON *tappets*





keep pace with today's engines

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MUSKEGON, MICHIGAN

Air Transports Need Auxiliary Power Unit

Based on paper by

J. L. BARTLETT

and

P. C. SCOFIELD

AiResearch Mfg. Co.

AN airplane in the air is completely independent, but stopped at the ramp it is as helpless as a newborn babe and has to be kept alive by a horde of ground support vehicles and equipment. With the advent of the turbine-powered transport, the clutter may become worse because of the need for a new and different type of service for engine starting.

A gas turbine auxiliary power unit aboard the transport would be the most convenient way to supply ground air conditioning, electrical power, and pneumatic power for engine starting. It would also eliminate a great deal of the clutter. Power requirements, which may exceed 100 hp with turbine powered transports, permit a turbine form of starter to show a significant weight advantage over an electrical starter.

Another advantage of the auxiliary gas turbine is to be had in the prolonged engine cranking that it permits. This would make possible checking engine fuel and miscellaneous accessory and control systems, as well as blowing out of engine tailpipe fires.

The ratio of fuel consumed at idle to that consumed at cruise power is many times greater for turbine engines than for reciprocating engines. The T-56 turboprop engine, for example, consumes 610 lb per hr at idle. Two engines will be required to supply system energy on the ground and at crowded airports an average of about 15 minutes hold time will be required for take-off clearance. Practical operation might call for 30 minutes of fuel for such holding operations. Thus, 610 lb of fuel would be required of which 305 lb might be burned. It follows, therefore, that shutting down the main engines and using the auxiliary gas turbine aboard to provide necessary services during the hold condition will save enough fuel weight (average) to equal or be greater than the weight of the auxiliary turbine installation.

CONTINUED ON PAGE 116

Since 1912 . . .

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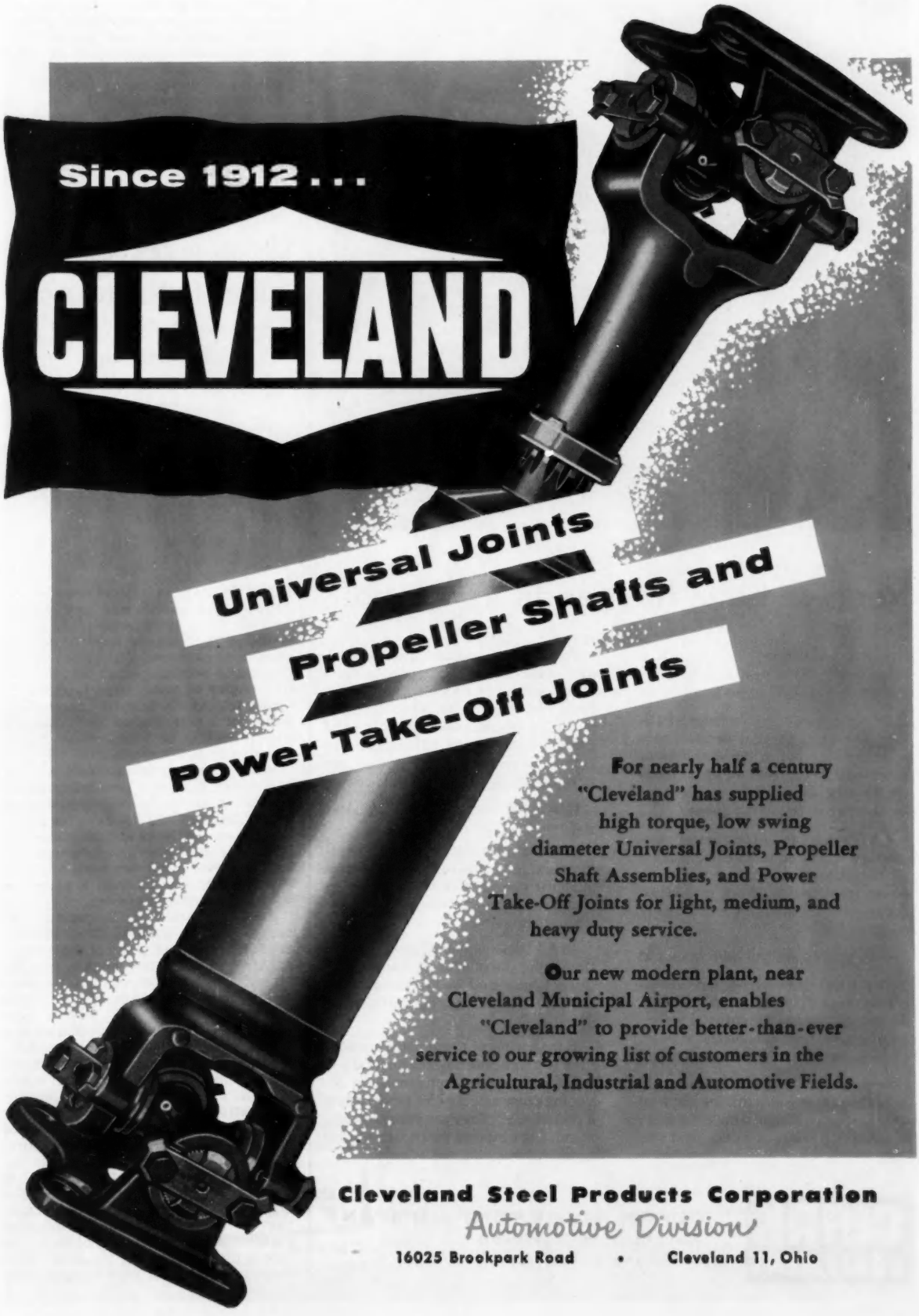

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Our new modern plant, near Cleveland Municipal Airport, enables "Cleveland" to provide better-than-ever service to our growing list of customers in the Agricultural, Industrial and Automotive Fields.

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Automotive Division

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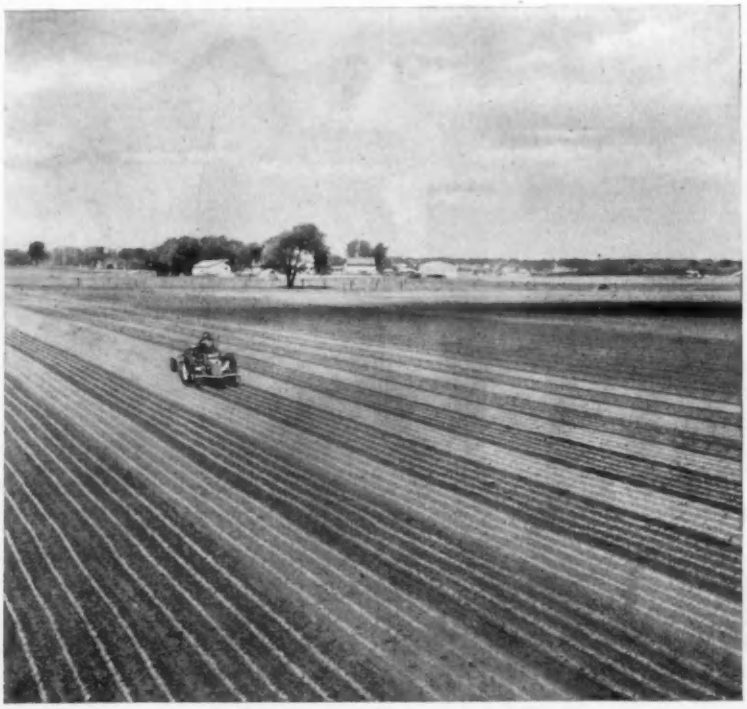

Yes, we have hayseeds in our hair

You don't ordinarily associate Clark Equipment with the business of farming, but we're in it—and in no small way.

On crop acreages, drainage, fertilizers, feeds and the like, we don't pose as authorities; but in the vital area of power equipment, without which modern farming wouldn't be modern, we know what we're talking about.

• A few years ago an implement manufacturer called us in. Said he, in effect —"We know power-farming, you know power transmission. Work with us to design what a tractor drive unit really ought to be."

• We jumped at that—who wouldn't?

Step 1 was to sweep out the rubbish of traditional thinking; and particularly the old idea that a conventional assembly of engine, transmission and axles on a frame constituted an industrial chassis.

Step 2 was to conceive, test and build an axle-transmission driving unit of truly functional design, stripped of every non-essential ounce of metal. That was done.

This intelligent collaboration seemed to us at the time, still appeals to us now, as the best way we know of to build a better machine: this pooling of a manufacturer's operations experience and Clark's half-century of engineering know-how in the basic field of power transmission.

Interesting sequels to that incident are two:

1. Other manufacturers of agricultural and industrial machinery, always alert for constructive ideas, called in Clark engineers—with equally gratifying results.

2. All those manufacturers are still thoroughly satisfied with their Clark Drive Units—and we are just as satisfied with the business of manufacturing them.

Is there a place at your planning table for Clark's engineering imagination and ingenuity and resourcefulness—for designing a new model or for modernizing a present one? They are yours to command. Let's explore the mutual advantages. A letter will make contact.

CLARK® EQUIPMENT

CLARK EQUIPMENT COMPANY
Automotive Division
Buchanan 5, Michigan

The fire hazard with an auxiliary gas turbine is no greater than that associated with the main engines, combustion heaters, or fuel air starters. (Paper "Auxiliary Power and Air Conditioning for the Self-Contained Airplane" was presented at SAE Golden Anniversary Aeronautic Meeting, Los Angeles, Oct. 14, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Clinical Inspection A Boon to Maintenance

Based on papers by

R. W. BOLAND
Joseph Weidenhoff, Inc.

WALTER E. DAVIS
Cleveland Transit System

H. A. GRENERT
Cincinnati, Newport & Covington Street Railway Co.

and

W. W. SQUIER
Sun Electric Corp.

TODAY'S engines are far more exacting of fuels, carburetion, and ignition systems than their predecessors. In terms of fleet maintenance these engines have narrowed tolerances in making initial settings or adjustments of the engine's most important parts. Closer tolerances, in turn, create a demand for a new type of mechanic, one who is willing to augment his native senses with instrumentation.

With instrumentation made simpler and easier, standard preventive maintenance procedure advances to clinical inspection. The former calls for maintenance on a mileage or time inspection basis; the latter goes a step further and removes from a mileage basis any unit that can be checked with a gage. In short, gages replace guesses.

As an example of instrumentation can be cited an oscilloscope which permits observation of many of the components of an operating engine. In excess of 25 ignition checks can be made on battery and ignition systems while the engine is running. Piston rings and valve action can be studied as well as compression factors. The oscilloscope reveals compression characteristics in a manner impossible with a static test, particularly with the modern short-stroke engine.

Cincinnati Transit makes very good use of magnahelic gages in its clinical inspection. One gage is used on the inlet side of the air cleaner, another is used on the outlet or blower side. The difference in reading indicates condition of the filter. When depression reaches 20 in. through the filter, the unit is disassembled for cleaning. Previously, air cleaners were dropped every

We stop them all—Safely

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THE SAFETY BRAKE LINING

AMERICAN Brake Shoe COMPANY

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AMERICAN BRAKEBLOK DIVISION
DETROIT 9, MICHIGAN

4000 miles, oil changed, and the cleaner sloshed in a solution, then drained and reinstalled. Yet gages showed the cleaners still dirty. Now, with a new solution, filters are restored to original cleanliness in 30 min. of agitation, and the savings in oil replacement alone totalled $287 last year on its diesel fleet.

Probably the cooling system is the most neglected system of the engine in inspection and maintenance. If a mechanic will use a surface pyrometer he will become conscious of the cooling system and be able to master trouble quickly and unerringly.

The pyrometer has many uses. It can be employed to set up satisfactory brake balancing standards and to check individual brake operating conditions. Tests show a direct relation between brake drum temperature and wear rates. The condition of injectors on two-cycle diesels can be determined by checking exhaust outlet temperatures. Defective injectors will cause a change in temperature.

(Papers "A Fresh Approach to Ignition Analysis"—Boland, "Clinical Inspection"—Davis, "Clinical Inspection"—Grenert, and "Instrumentation in Fleet Maintenance"—Squier, were presented at SAE Golden Anniversary Transportation Meeting, St. Louis, Nov. 1, 1955. They are available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

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SMALL MOTORS
Leece-Neville
LOW VOLTAGE DC
to your specs
Does your product require a d.c. motor in this range: 6 to 32 volts; .002 to .08 h.p. (1½ to 60 watts output); 2,000 to 4,000 r.p.m.? Leece-Neville high-efficiency motors feature precision formed frame; self-aligning, sintered bronze bearings; large reservoir and automatic oil return for reliable lubrication; machine-wound coils. Stack lengths from ⅝" to 1⅝". A producer of small motors in the millions, Leece-Neville will work to your specifications on substantial production runs. The Leece-Neville Co., Cleveland 3, Ohio. Automotive Electrical Equipment Since 1909.
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ALTERNATOR SYSTEMS • GENERATORS
STARTING MOTORS • REGULATORS • SWITCHES
TRUCK
BUS
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PASSENGER
RAILROAD
MARINE
INDUSTRIAL

How B-52 Duct Bellows Failure Was Overcome

Based on paper by

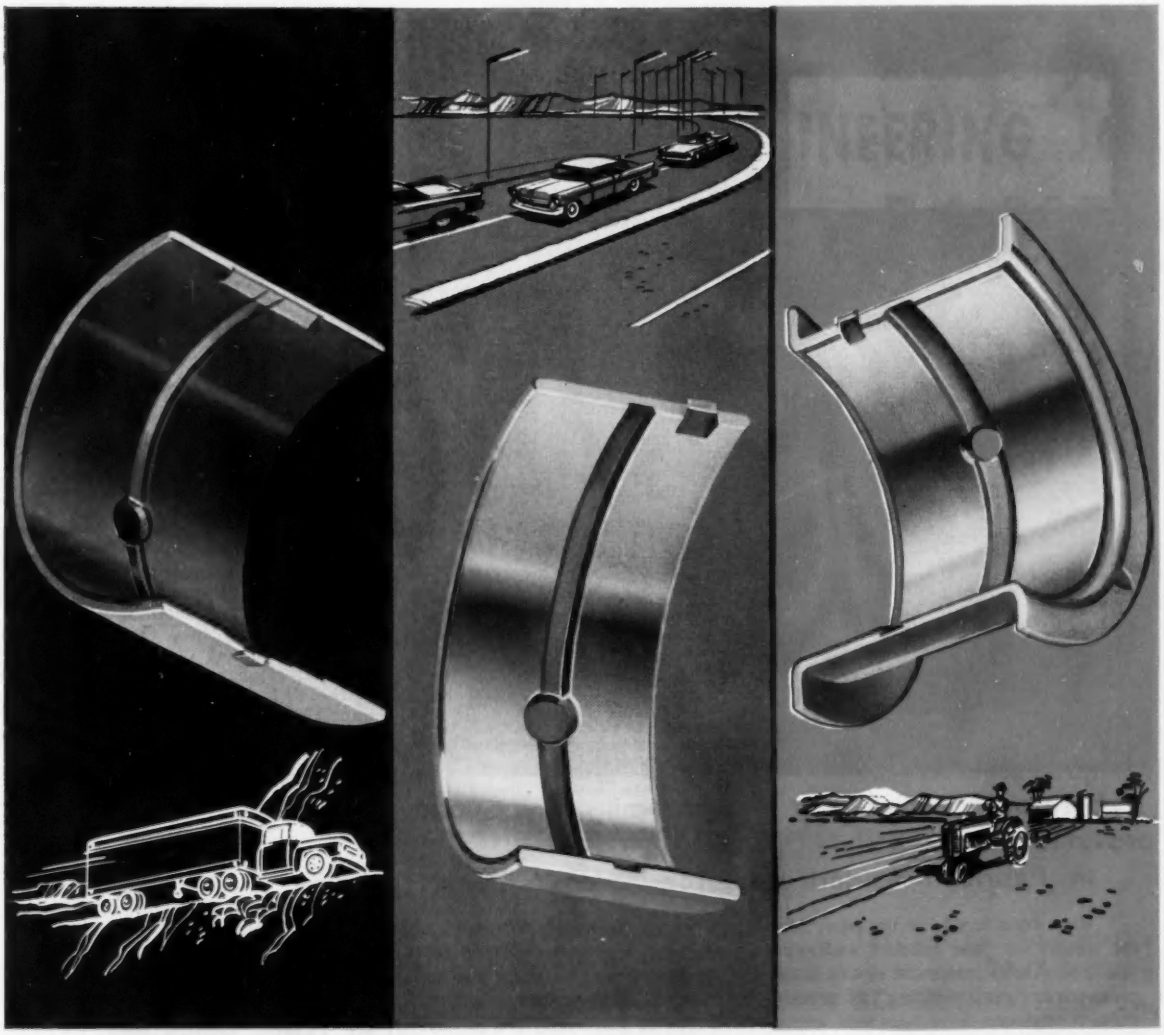
C. R. PETERSON

Boeing Airplane Co.

THE original design of the XB-52 airplane utilized flexible stainless steel bellows throughout the pneumatic duct system to accommodate the thermal expansion growth. As a result of experience gathered from the experimental airplane and from extensive laboratory tests, a full tension duct system was incorporated in the body of the production B-52. Thermal expansion, duct misalignment, and structural deflection are absorbed in the wing, struts, and nacelles by bellows. This is accomplished in the body by expansion loops, omega bends, and where possible, by the inherent flexibility of the normal duct configuration.

While investigations were being made of the duct stability problem, a bellows cracking problem developed during test of the half-system mockup. This test configuration was a mockup of half the pneumatic system set up to study operational characteristics and functions of the pneumatic system. Air was supplied by a compressor capable of producing 8.5 lb of air per second at 160 psig. Previously cracks had been detected in the parent metal on the exterior surface of the bellows, and after thorough investigation had been attributed to improper fabrication techniques. Changes in fabrication methods were made by the vendor and it was on these bellows that the new cracking problem was observed.

Tests were conducted to evaluate the individual effects of temperature, pressure, stroke, and airflow on the bellows. From these it was determined that cracking was caused by the high weight flow of high-temperature, high-velocity air. Crack-free bellows received from the vendor could be cracked in a few minutes when subjected to the airflow of 8.0 lb per sec at 90 psig. The high-velocity air passing over the convolutions was found to produce detrimental frequencies of vibration



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Typical reinforced plastic parts produced by Fabricon for the automotive industry

Laboratory control over new premix compounds provides GREATER UNIFORMITY OF STRENGTH in Fabricon-molded reinforced plastic parts!

Ever considered the use of reinforced plastic molded parts to *improve* the quality of your product and *reduce* manufacturing costs, too? If so, you'll be *doubly* interested in this latest development from Fabricon. For as pioneers in "gunk molding" of premix compounds, Fabricon chemists and process engineers have been well aware of the lack of uniformity commonly encountered in many such molded parts. That's why, during the past 5-years, they've made it their business to find ways and means of overcoming this obvious limitation. By the selection of proper basic materials to meet specific application requirements. And, too, by the development of special laboratory controlled processing techniques which assure consistent quality in the volume production of intricate, complex parts. As a result, Fabricon's new premix plastic moldings now possess far greater uniformity of strength than heretofore thought possible . . . plus a host of other desirable properties which highly recommend their use on countless different products, *yours included!*

Want more detailed information? Just outline the requirements of your particular application and send them in today!

PHYSICAL CHARACTERISTICS	PREMIX COMPOUND	
	MP-196 (Sisal)	MP-162 (Glass)
Flexural Strength, psi	11,200—13,400	14,800—19,300
Modulus of Elasticity in flexure—10^6 psi	1.17 — 1.40	1.20 — 1.72
Izod Impact Strength, foot-pounds/inch of notch	4.2 — 5.4	8.3 — 8.3
Water Absorption, % 24 hr.	1.78 Average	0.65 Average
Heat Distortion Temp.	382°F.(+)	382°F.(+)

Above values based upon tests conducted by independent laboratories in accordance with ASTM methods. Compounds listed are latest of over 150 grades developed and produced by Fabricon. Sample test panels gladly furnished upon request.

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which caused the cracking failures. Use of a suitable liner on the inside of the bellows reduced the vibrations sufficiently to overcome this problem and make possible a satisfactory service life.

In addition to adding a liner, procurement specifications were revised to include the following qualification test requirements:

1. An axial fatigue test of 20,000 cycles at conditions of 150 psig and 500 F.

2. A stability test incorporating four bellows interconnected by three 80-in. sections of work-hardened ducting with suitable lateral offsets and deflections induced.

3. A flow life test using airflows at the rate of 8.0 lb per sec at a temperature of 690 F, 70 psia and velocities up to 800 fps.

Revised bellows passed these tests successfully and subsequent service experience on the experimental airplane has indicated the achievement of a stable, structurally sound bellows.

(Paper "Problems Encountered in the Development of the B-52 Pneumatic Ducting System" was presented at the SAE Golden Anniversary Aeronautic Meeting, Los Angeles, Oct. 14, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Too Many Guesses In Truck Selection

Based on paper by

ROBERT CASS
The White Motor Co.

TRUCK maintenance costs definitely above normal as well as those considered acceptable can be reduced by taking the following steps:

- Make detailed study of the operation, including payloads expected and terrain to be covered.

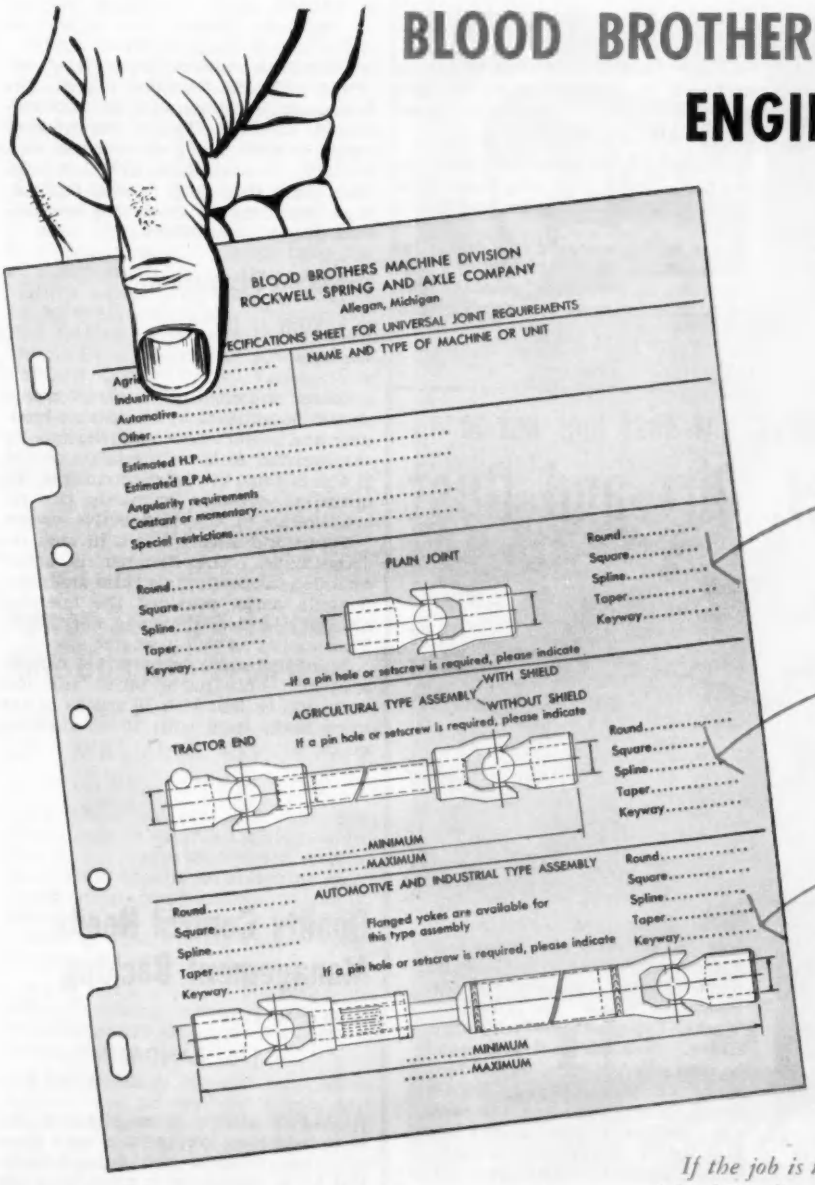
- Place trucks in the same light as any production tool in a well regulated manufacturing company.

- Pay particular attention to component selection—not only the load-carrying capacity of rear axle, but also the ratio to be selected.

- Study engine size and take into account engine miles in terms of piston velocity per mile of operation.

- Study the transmission that goes with engine selection so that road speeds can be fitted best to the terrain

BLOOD BROTHERS makes your ENGINEERING JOB *EASIER*



. . . regardless of whether your project requires a single universal joint such as this

. . . a complete agricultural type assembly

. . . or an automotive or industrial truck propeller shaft like this

Just fill out and mail a sheet like *THIS*—and let BLOOD BROTHERS' Engineers propose a helpful, practical solution to your Drive Line Problem!

If the job is unusual or the problem unique, Blood Brothers' experience can be invaluable.

Many engineers are saving valuable time—right at the start of a project—by filling out and returning a "Spec Sheet" like this to Blood Brothers. Why not try it?

With your power transmission requirements in mind, our engineers will make recommendations and submit engineering drawings. You save designing and drafting time, and perhaps forestall problems, by having the initial teamwork of experienced specialists.

This service is offered without extra charge because *we* can work more efficiently with all the facts in hand.

Blood Brothers builds *more standard types and sizes* of universal joints than any other manufacturer (from 300 up to 89,300 torque inch pounds continuous load).

Why not use this experience on your next project? *Write Blood Brothers today for your handy "Spec Sheets."*

BLOOD BROTHERS MACHINE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

and engine miles reduced correspondingly.

• Have a definite set of specifications agreed upon and signed by the truck manufacturing company representative to indicate that he in turn has analyzed the operation and is making definite recommendations against known facts.

• Take advantage of the "standard times" developed for maintenance and repair operations.

• Study what special tools should be purchased on basis of manufacturer's recommendation for maximum reduction in maintenance time.

• Examine tire sizes in relation to their cost and their effect on some components such as engine and transmission.

It can be fairly stated that there has been too much guesswork and too little calculation in selection of motor trucks. The problem cannot be solved readily or efficiently unless study is given. (Paper "Vehicle Selection and Its Influence on Maintenance Cost" was presented at SAE Golden Anniversary Transportation Meeting, St. Louis, Oct. 31, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Based on Discussion

H. L. Willett, Jr.
The Willett Co.

Design and engineering specifications should be outlined by the design engineer and performance specifications by the operator and maintenance people. If this is done, the detailed study of the operation becomes primarily the responsibility of the prospective owner.

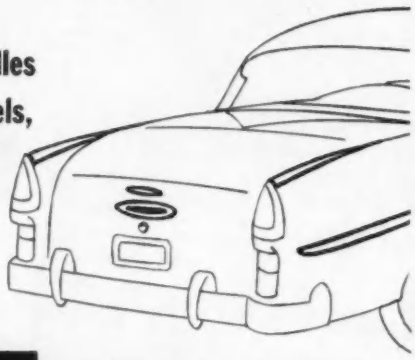
Compound selection is a divided responsibility. The designer is better qualified to specify axle ratio and components parts, provided the operator clearly specifies operating conditions. This applies as well to engine size.

Standardization should be considered also since parts, units, and tool costs will be less with 10 trucks of the same make than with 10 of different make.

Here's the most effective, low-cost lock nut to

Seal out Water, Dirt and Dust

when fastening
emblems, moldings and handles
on rear deck, quarter panels,
rear fenders, roof, etc.



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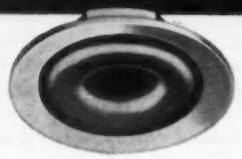

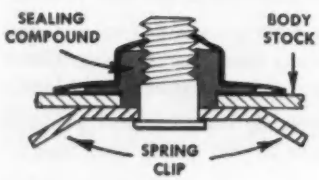

PALNUT Sealer-Type fasteners combine the functions of a nut, a lock washer, a flat washer and a sealer washer in a one-piece fastener. Essentially these are PALNUT Washer-Type fasteners with a resilient, clean plastisol compound bonded securely to the washer face. Body enclosures are effectively sealed against water and dust seepage. Significant cost savings and high speed assembly are achieved with PALNUT Sealer-Type Fasteners.

ADVANTAGES

Positive sealing. As nut is tightened, hollow hex design forces sealer around screw threads and into stud clearance hole.

Maximum thread sealing. Hollow hex, single-thread design allows several threads to be sealed.

Bonded sealer does not distort or come off during shipment or assembly.

Easy starting. Sealer does not bind in the threads; permits finger starting.

Resilient locking action avoids stud damage and body dimpling.

Write for free samples, details sizes, prices.

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Quality Control Needs Management Backing

Based on report by

J. S. RANDALL
General Motors Corp.

QUALITY control is an effective tool to help meet competition on a basis of price, quality, and dependability. But to be successful it must have the wholehearted support of management.

When this support is given, a program can bring about reductions in consumer complaints, scrap, re-work, and inspection costs. By using frequency distributions, histograms, together with average and range control charts, a quality control engineer can evaluate machine capability and tool life. If there is great diversity of product, a cell chart can be used. This has the advantage of using one chart per machine for all parts and all tolerances processed on it.

While based on an average and range chart, each cell on the vertical scale represents one-tenth of the tolerance for the part checked. The machine is checked for capability tolerance, then five-piece samples are taken for any part with any tolerance that goes over the machine. In the case of multi-

spindle machines, each spindle is treated as an individual machine.

(This article is based on the secretary's report of Forum on Quality Control and Its Relation to Production and Engineering held at SAE Golden Anniversary Tractor Meeting and Production Forum, Milwaukee, Sept. 12, 1955. Members of the Panel were: Leader: Arthur Bender, Jr., Delco Remy Div., General Motors Corp.; Secretary: J. S. Randall, General Motors Corp.; Members: Dale Cue, A. O. Smith Corp.; M. R. Fuller, International Harvester Co.; Warren Jones, Consulting Service; H. E. Maxwell, Caterpillar Tractor Co.; E. J. Oakley, Delco Remy Div., General Motors Corp.; Bert Seipel, Studebaker-Packard Corp.; L. K. Vollenweider, Deere & Co. The report is available together with six other panel reports as SP-112 from the Special Publications Dept. Price: $1.50 to members; $3.00 to nonmembers.)

Power Steering Trends Hint Ultimate Design

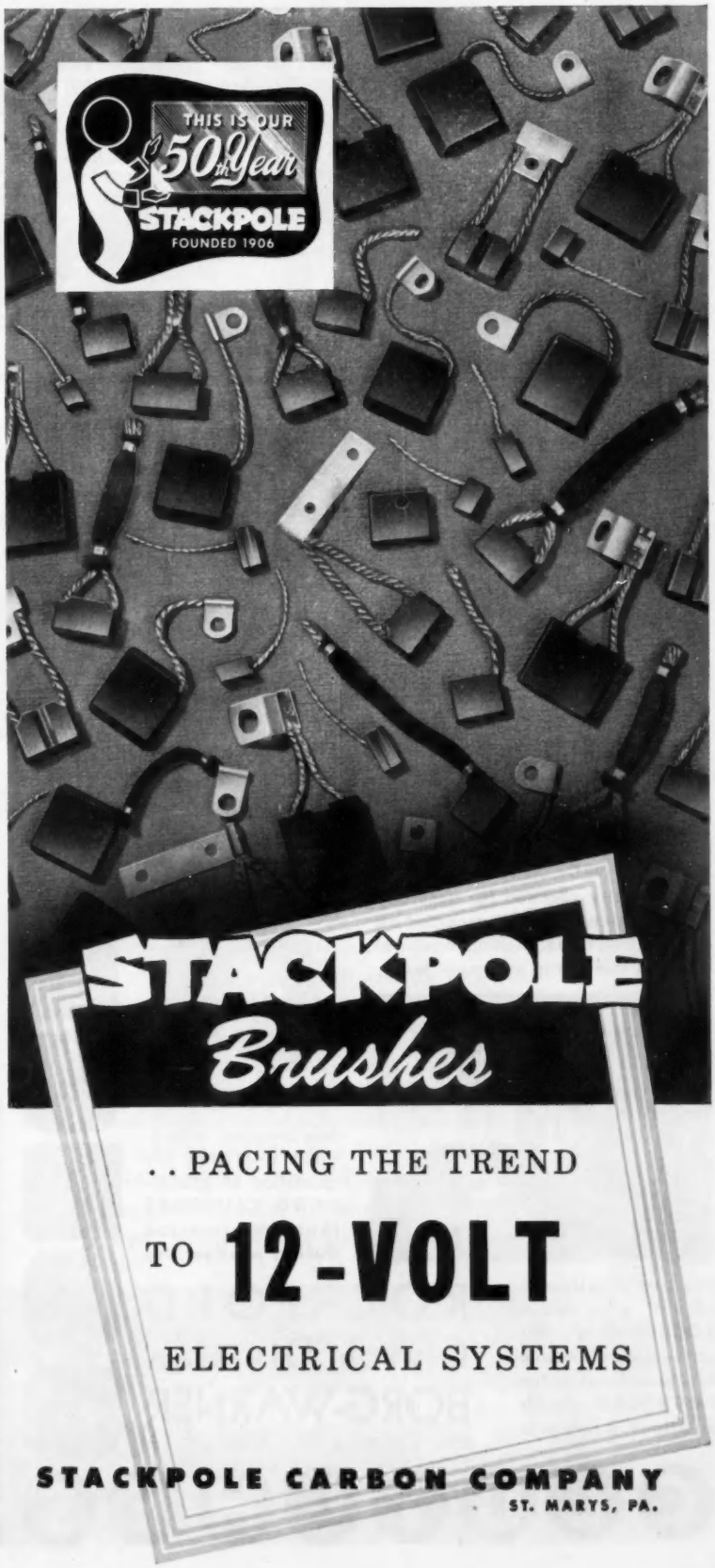
Based on paper by

WILLIAM K. CRESON
Ross Gear & Tool Co., Inc.

A lot more mileage and experience will have to be rolled up before any one or two particular power steering designs win dominance and bring about a desirable standardization. Trends do, however, show a settling out of design.

Here is what the experts see ahead for power steering:

- The trend is toward integral gears, although linkage power is attractive for commercial and a great variety of special vehicles.
- Thousands of miles of satisfactory service have proved the adaptability of air steering. Since power is obtained from the air brake compressor, practically no added accessory horsepower is required.
- A combination of valve-on-gear and actuator, mounted conveniently but separately is appearing on installations.
- By 1958, passenger cars will be equipped with power steering at the same rate as automatic transmissions.
- The success of any system depends on how well the geometry is worked out and on the quality of components and fittings.
- Integrating the power system with the basic chassis design will further the development of simple, compact, and economical units at moderate cost.
- Hydraulic power has given better control than electrical or mechanical power.
- Advanced thought in regard to hy-



draulic steering gears is directed toward simple, compact, economical integral designs.

• The overwhelming majority of farm tractors being built today are being equipped with power steering. If the unit price is dropped to a satisfactory figure within the next few years, such steering should become standard equipment, at least on the larger sized tractors.

• The hydraulic pump required for power steering might well be used for other purposes in addition, such as for applying power brakes and wiping windshields. Developments along this line are in the offing.

• Power steering on heavy duty trucks should be restricted to off-highway and city operation until the mechanism can be developed that is free of friction. To make the slight correction necessary for cross winds or crowned pavements, the efforts are higher and the straight ahead steering more difficult when power is used.

• Power steering actuators should be located near the steered wheels and all heavy steering forces should be contained within the front axle or equivalent assembly. This will require some changes in front end design, but it will stress fewer parts and eliminate reinforcement of frames, steering gear mountings, and drag links.

(Paper "Power Steering in 1955" was presented at several SAE Section Meetings during September 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

ROCKFORD

MEMO—clutch must have accurate balance

All ROCKFORD clutch plates not only are carefully checked for accuracy of dimensions, but are inspected on an electronic balancing machine. Uniform operation, minimum wear,

SPRING

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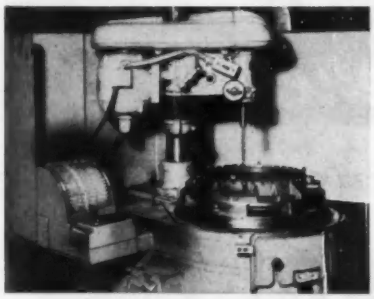
less frequent adjustment and long life qualities of ROCKFORD CLUTCHES thus are protected during production.



Let our engineers show you how ROCKFORD quality safeguards insure low maintenance for ROCKFORD clutch equipped machines.

ROCKFORD
Clutch Division
BORG-WARNER
316 Catherine St., Rockford, Ill.

CLUTCHES

Incentive Programs Cut Maintenance Costs

Based on paper by

W. W. VANDERCOOK

F. J. Boutell Driveaway Co., Inc.

INCENTIVES are the key to increased production, better employer-employee cooperation. A service employee may get the feeling that his job is unimportant. If that thought becomes contagious it can be ruinous. A good incentive plan based on individual or group effort toward certain company benefits will give the employee a sense of belonging, leading to the development of good rather than bad traits.

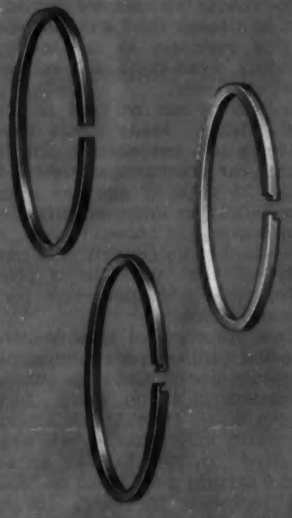
Our incentive plan includes the honor roll system and additional points in our annual contest and prize award system. Some of our drivers do not merit the award of points and points are deducted from their score. But we try to make the publicity on point additions impress more than the point deduction.

Maintenance employees are now included in our incentive plan, their point awards being based on road failures. A driver must now face the criticism of the mechanic if he is guilty of abusing his tractor or trailer. Mechanic-driver discussions go far toward training the driver, since the mechanic may teach how to avoid certain failures, or how to foresee them.

Paper tests for drivers should center around their mechanical knowledge of a piece of equipment and the proper handling of it. If a driver lacks this knowledge, he should be trained, for it is just as important as teaching him the rules of the road. The trainer should be a specialist, able to impart some mechanical knowledge as well as driving instruction. The driver should be told, for example, that if he drags his brakes going down a long hill, overheated drums cause brake fading, and that he can prevent it by intermittent sharper applications. If he lugs the

A lot more than $64,000 can depend on the question:

WHAT SEALING RINGS SHALL WE USE?



Automatic transmissions require them. Power steering requires them. One engineering mistake could run into big money fast.

Experience helps avoid mistakes. Sealed Power has had more experience with sealing rings than all other ring manufacturers put together.

Eighteen years ago Sealed Power made the first sealing rings, for use in tanks. Now Sealed Power makes them for cars, trucks, and buses. Sealed Power has made considerably more than half of all the sealing rings that have ever been manufactured. The total is close to a hundred million rings!

You are invited to use this experience whenever you face any sealing ring problem.

SEALED POWER CORPORATION • MUSKEGON, MICHIGAN • ST. JOHNS, MICHIGAN • ROCHESTER, INDIANA
DETROIT OFFICE • 5-164 GENERAL MOTORS BUILDING • PHONE: TRINITY 1-3440

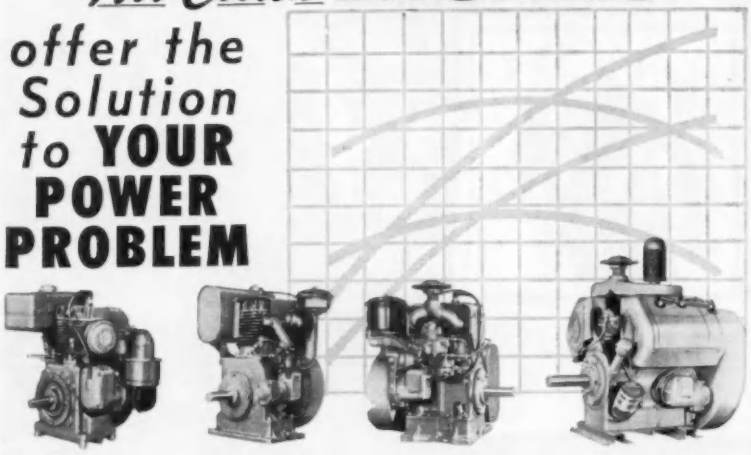
Sealed Power Piston Rings

PISTONS • CYLINDER SLEEVES

Leading Manufacturer of Automotive and Industrial Piston Rings since 1911
Largest Producer of Sealing Rings for Automatic Transmissions • Power Steering Units

WISCONSIN Heavy-Duty *Air-Cooled* ENGINES

offer the Solution to YOUR POWER PROBLEM



Single cylinder 2.3 to 6.8 hp. | Single cylinder 6 to 9 hp. | 2-cylinder 7 to 15 hp. | V-type 4-cylinder 15 to 36 hp.

Next to the basic machine itself, one of your major problems, quite obviously, is to select and specify a power component that matches both the machine and the work it is to do . . . *most advantageously*. Wisconsin Heavy-Duty Air-Cooled Engines merit your critical and serious consideration because:

- Every Wisconsin Engine is of HEAVY-DUTY design and construction in all details . . . with the inbuilt stamina to *take it* under all operating conditions, in any climate, at all temperatures from extreme sub-zero to 140° F.
- The Wisconsin lines provide the most complete power selectivity to fit both the machine and the job . . . 12 different models in 4-cycle single cylinder, 2- and V-type 4-cylinder types, in a power range from 3 to 36 hp.
- Servicing of your equipment will be safeguarded by more than 2000 authorized Wisconsin Engine distributors and approved service stations in the United States and Canada.
- In world markets your Wisconsin-powered equipment will be supported by authorized Wisconsin Engine distributors and dealers in 82 countries, carrying service parts and replacement engines.

We will be glad to co-operate with you in adapting Wisconsin Heavy-Duty Air-Cooled Engines to your original equipment *most advantageously*. Tell us about your power problem. Specification bulletins and engineering data available on all Wisconsin Engines.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

A 8702-½-IAA

engine before shifting, it is not enough to mention that the rpm's must be kept above a certain minimum. He should be told that it is hard on bearings and tends to loosen them.

Some fleet operators have an instructor whose duty it is to find out why a driver has a higher than average accident rate, maintenance expense, or gas consumption, and make the necessary corrections. In rare instances the gasoline that is charged may not be put in the tank, but records soon point the finger at cheaters and they can be eliminated. (Paper "The Driver and His Influence on Maintenance Cost" was presented at SAE Golden Anniversary Transportation Meeting, St. Louis, Oct. 31, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Highway Safety Work Needs Better Approach

Based on paper by

RALPH J. CROSBY

Marsh & McLennan

HIGHWAY death statistics indicate that existing appeals have been ineffective, perhaps because the approach has been too mild. People need to be shocked. Instead of tolerating the driver who boasts of his daring and hair-breadth escapes we should treat him as a sneak thief and publicize bad driving practices as the mark of a cheating, weak-minded, dumb, or disloyal character.

Incentives can be used to promote safe driving. Many states have approved a 10% reduction in private passenger car premiums where the driver under 25 years of age has completed successfully an endorsed driver education course. In Massachusetts, reconsideration of its demerit plan has been proposed with the idea of providing preferential premium rates for good driving records.

Law enforcement is a positive and effective medium for changing people's attitudes quickly and some outstanding achievements are on record. In Washington State, for example, all-out war on traffic killers has shown what can be done. In 1942 to 1952, an average of 7.9 persons were killed on Washington highways for every 100 million miles driven. In 1954 the average dropped to 4.4, and in the first six months of 1955 it fell to 3.8. Cost of extra equipment and manpower for this program has been just under $10,000. (Paper "What Is Ahead in Automotive Safety" was presented at SAE Metropolitan Section Meeting, New York, Nov. 3, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

New Members Qualified

These applicants qualified for admission to the Society between December 10, 1955 and January 10, 1956. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

William Ross Davis (J).

Baltimore Section

Richard L. Colgan (J).

Canadian Section

Cecil E. Bovaird (J), Ernest N. Chorny (J), David H. Connell (M), Thomas J. Maloney (M), Duncan Munro McLaurin (J), Robert J. I. Scott (J).

Central Illinois Section

J. C. Bollier (M), Charles L. Ellis (A), Richard W. Luttrell (J), Francis S. Robinson (M), Randolph E. Seyfried (M).

Chicago Section

Harold R. Boatman (M), Charlie N. French (J), Fredrick W. Gibbs (J), Richard J. Lambert (A), William W. Nugent (J), James H. Sheffler (A), Robert W. Temple (M).

Cincinnati Section

Rowland James Hill (M).

Cleveland Section

Joseph August, Jr. (M), James A. Bailey, Jr. (A), Charles F. Bush (M), R. E. Saxton (M).

Colorado Group

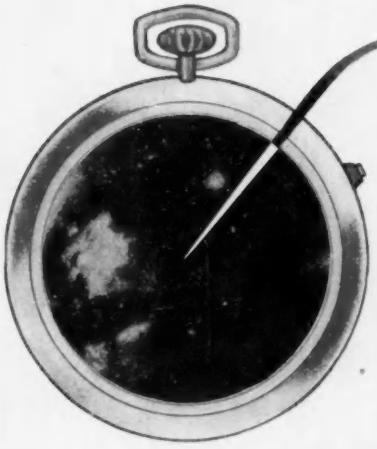
Lee R. Sollenbarger (A).

Dayton Section

John L. Biedenbach (J), Robert P. Donley (J), Norman L. Gebhart (M), Melvin J. Helmich (M), Arthur F. Pelster (M), Vernon L. Shatz (M).

Detroit Section

Roger L. Aldrich (J), Benjamin W. Badenoch (M), Budd N. Barclay (J), Frederik Barfod (M), Robert T. Bergman (A), John M. Berndtson (J), Bruce Charles Brede (J), William C. Bright, Jr. (J), Ernst Bunning (J), Thomas F. Burke (A), Francis P. Dean, Jr. (J), Edward E. Donaldson (J), William L. Drayer (J), Howard G. Foell (J), Ivan M. Francis (M), George Gerdan, Jr. (M), Gilford E. Gorker (J), Thomas J. Guirey (A), Richard E. Hanslip (M), C. O. Jackson, Jr. (A), William G. Keil (M), John J. Killinger (J), Frank E. Manion (J), John J. Mears (J), Francis E. Murphy (J), Robert L. Pence (J), Edward L. Richardson (J), Walter H. Riley (A), Casimir Rogo (J), Donald James Smith



Engineers whose minds travel 7 miles per second*

find a rewarding future in rocketry at

REACTION MOTORS

Here are futures not bounded by the narrow limits of specialization or regimented production. At Reaction Motors, YOU are the engineer.

The problems provoked by man's determination to conquer time and space, to establish service satellites, to master the force of gravity and to develop precision in rockets will challenge your creative abilities. And the solutions add immeasurably to your professional stature.

Here at RMI you have at your disposal the tremendous research facilities and the accumulated technical skill gathered through 14 pioneering years of rocket research and development. All the important speed and altitude records for planes and single stage rockets are held by aircraft or missiles powered by engines developed by Reaction Motors.

If you ARE an engineer whose mind travels 7 miles per second, you'll reap a richer harvest at RMI. And you'll enjoy working in a completely equipped, brand new four million dollar plant in the heart of New Jersey's lake and mountain resort area, just 50 minutes from New York City.

We Have Immediate Openings For Men With Experience or Training In The Following Fields:

- Stress Analysts—Aircraft Engines or Airframes
- Environmental Testing of Components
- Aircraft Power Plant Installation
- General Project Engineering Work
- Engine Controls and Controls Systems
- Design of Airframe or Aircraft Engine-Type Parts
- Servo-Mechanisms
- Solid Propellant Grain Design for Seat Catapult Ejection Systems
- Thrust Chamber and Injector Design and Combustion Stability
- Design and Development of Hydraulic, Pneumatic and Mechanical Components and System Synthesis
- Analysis and Consultation on Rocket Engines and Power Plant Systems
- Formulation of Control System Problems, Computer Set-Up and Solution Analysis
- Rotating Machinery Design and Consultation
- Rocket Engine Testing and Instrumentation
- Internal Combustion for Jet or Rocket Engine Applications
- Preliminary Design or Proposal Experience in Aircraft Power Plant Field

RMI

REACTION MOTORS, INC.

"First in Rocket Power"

FORD ROAD DENVILLE, N. J.

AFFILIATED WITH THE OLIN MATHIESON CHEMICAL CORP.

Send Complete Resume Including Experience & Salary Requirements to Employment Manager

*Earth's Escape Velocity

New Members Qualified

continued

(M), Joseph E. Stoyack, Jr. (J), William C. Strom (J), James Thomas (M), Preston T. Tucker, Jr. (A), John S. Wagoner (A).

Indiana Section

Walter A. Brighton (J), Ronald S. Harrelson (J), Gordon C. Sylliaasen (J).

Kansas City Section

G. T. Hahn (A), William E. Wagar (M).

Metropolitan Section

Nick H. Devletoglou (J), Herbert Erickson (J), Bruce Philip Fow (J), J. Thomas Morrow (J), Herbert A. Whitney (J).

Mid-Continent Section

Robert N. Collins (J), Daniel M. Gibson, Jr. (J), Nicholas Ignatovich (J), William Bruce Pate (A), Bennie Shultz (J).

Mid-Michigan Section

Paul E. Jaquish, Jr. (J), William Robert Martin (J), Ronald C. Treloar (J) John C. Zehnder (J).

Milwaukee Section

Walter H. Zirzow (M).

Montreal Section

Francis V. Guimont (A).

Northern California Section

Archer F. Neider (J), John W. Salter (J).

Northwest Section

James R. Landweer (J), John Reed Thayer (J), 2nd Lt. Arthur G. Walden (J).

Oregon Section

Andrew D. Rintoul (M).

Philadelphia Section

Andrew D. Grey (M), Ford Heritage (J), Walter E. MacDonald (J).

Pittsburgh Section

Harold G. Hall (M), Laurence A. Keim (M), Charles G. Purnell (M), James Kenneth Seatter (J).

St. Louis Section

Thomas A. Bauman (J), Milton J. Plomer (J), Richard Lee Schroeder (J).

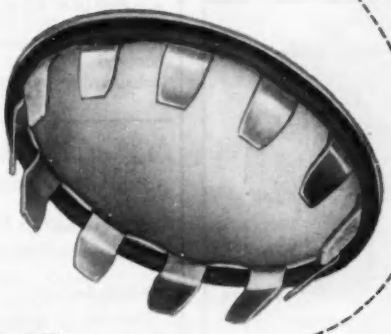
San Diego Section

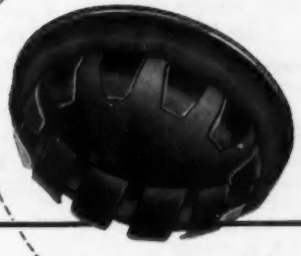
John B. Witt (J).

Southern California Section

Harry G. Bieker (J), Robert D. Brown (J), Eugene Bulac (J), Julian Carranza (J), Fred A. Cohan (J),

IT'S A "SNAP" to make a tight seal with DAREX Flowed-in Gaskets





W506 COMPOUND — one of several standard DAREX "Flowed-in" compounds now being used by the automotive industry.

Base: Buna	**Permanent Set:** 30%
Adhesion to metal: Good	**Curing Time:** 20 Minutes
Heat Resistance: 0°F to 250°F	**Consistency:** Uniform sponge
Oil Resistance: Good	**Uses:** Metal to metal seals against water, dust, dirt, fumes, vibration
Aging: Excellent	

Dewey and Almy does not make the "snap-in" parts shown. We supply their manufacturers with gasketing compounds and machines to apply them.

When "snap-in" parts are pre-gasketed by the DAREX "Flowed-in" Gasket Process:

- You *get* a tight seal that prevents vibration, seals out water, dust, dirt and fumes
- You *save* by eliminating costly hand assembly of gasket to part
- You *know* that there's no chance for a worker to drop or forget the gasket

Knock out plugs and electric socket housings typify a whole family of "snap-in" parts on which automotive manufacturers are saving thousands of dollars yearly by using the new DAREX "Flowed-in" Gasket Process.

The DAREX "Flowed-in" Process is ingeniously simple. A DAREX gasketing compound is *machined-flowed* directly onto the part. This "flowed-in" compound is then cured to form a solid, rubbery gasket which becomes *integral* with the part. Since part and gasket are joined as one unit, your assembly line installation is speeded up. And you get a *positive* seal at lower cost than ever before.

Send today for the DAREX "Flowed-in" Gasket Brochure. In pictures and text, it shows a variety of applications in which this fresh approach to industrial gasketing can save motions, time and money for you!

DEWEY and ALMY
Chemical Company
DIVISION OF W. R. GRACE & CO.
Cambridge 40, Massachusetts

New Members Qualified

continued

Donald E. Geiler (J), Arthur C. Haman (J), Patrick J. McGrath, Jr. (J), David E. Nothstine (J), Herman V. Schwalenberg (M), Toshiro Shiba (J), Frederic N. Smiley (J), Julian M. Smith (J), Billy L. Warren (J), Jack Weinroth (A).

Southern New England Section

George Anderson (J), Harry C. Marugg (J), Robert F. Ostrander (M), Jack S. Rubin (J).

Syracuse Section

George E. Ellis (A), Leonard J. Fiorito (A).

Texas Section

Harvey Edward Fisk, III (M), Jack Philip Holman (J), John S. Howell (M).

Texas Gulf Coast Section

Travis R. Shipp (M).

Western Michigan Section

William L. Olds (J), Jack R. Osborn (M), Richard E. Walton (J).

Witchita Section

Albin H. Swanson, Jr. (M).

Outside Section Territory

Wilmer J. Brice (J), Ernest D. Garrett (M), Lt. Herbert F. Herndon (J), Jamil Abdul Razzak (J), Lt. (jg) Clifford M. Rigsbee (J).

Foreign

Donald A. Bodley (J), Africa; Helmut Emil Hautle (M), Venezuela; Raymond Poncet (M), France; John Malcolm Rae (J), England; Giuseppe Raiteri (M), Italy.

Applications Received

The applications for membership received between December 10, 1955 and January 10, 1956 are listed below.

Alberta Group

Sidney A. Smith

Atlanta Section

Thomas A. Reed, Lewis A. Rumph

Baltimore Section

Charles D. Helm, Pell Kangas, John W. Lippert, Francis B. Rykoskey, C. H. Smith

British Columbia Section

Willis W. Brookman

Buffalo Section

Wendell D. Holcomb

Canadian Section

J. L. Gardner, L. Hunter, Paul E. Lavery, Frederick R. B. Matthews

Central Illinois Section

J. E. Staab

Chicago Section

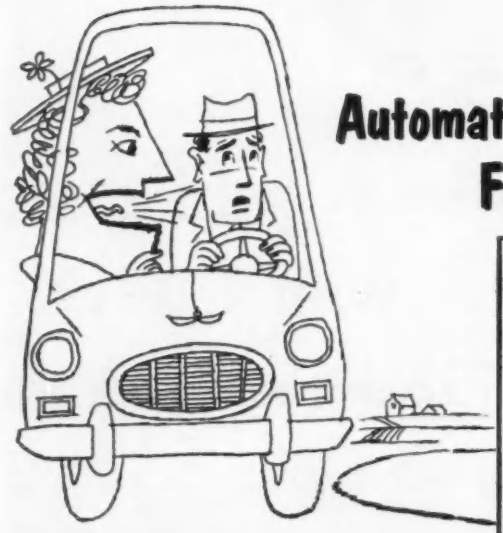
Robert G. Bielenberg, Roger S. Conrad, J. Arthur Gross, James G. Hanna, Anthony J. Jablonsky, Joseph J. Kaczmarski, Robert E. Lake, James M. McAvoy, Hamilton Migel, A. W. Risser, John E. Rosnell, Marvin Scadron, Walter E. Schock, William J. Siekman, Raymond Suchomel

Cincinnati Section

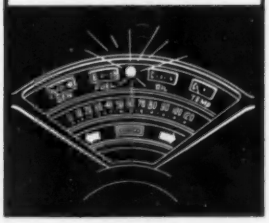
Gerald E. Briggs, Ralph Medros

Colorado Group

Chester L. Wentworth



Automatic Reminder For Motorists



FASCO

LOW OIL PRESSURE INDICATING SWITCH

The NEW FASCO "451" may be small; but . . . to the car owner, its essential protection against trouble and costly repairs is a BIG factor. And being a FASCO product, its unfailing dependability can be taken for granted. Sales-minded engineers are first to recognize its importance.

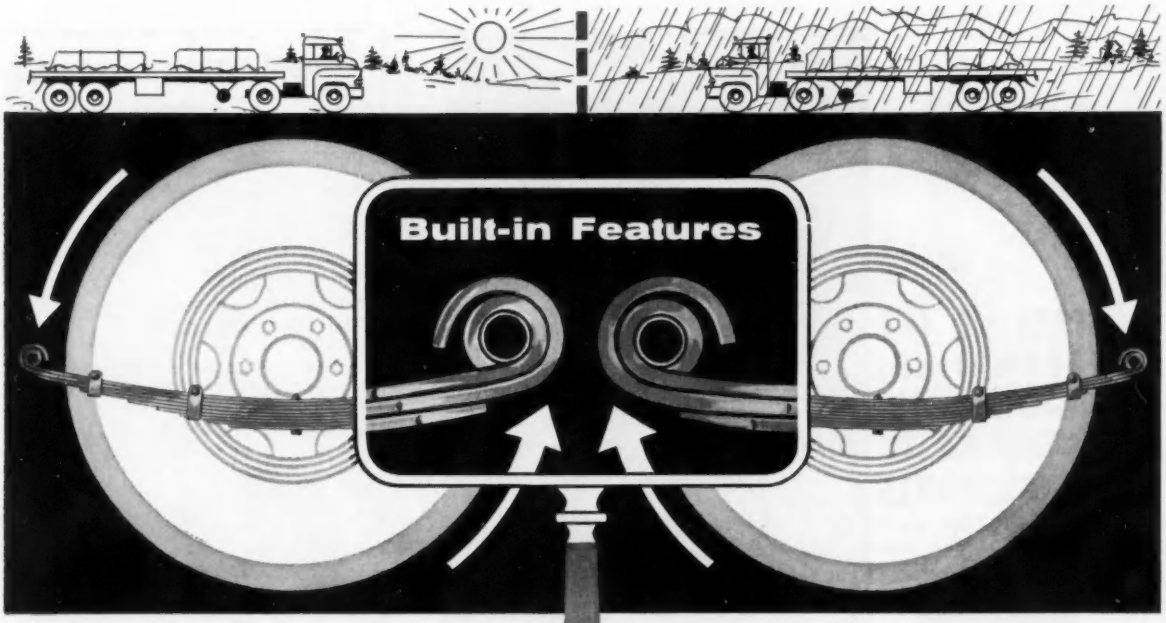
ON PUBLIC CARRIERS, the FASCO "451" also meets the need for a warning indicator of low pressure in the air-brake system. Remember... where dependability and economy in automotive design count, IT PAYS to . . .

AUTOMOTIVE DIVISION FASCO INDUSTRIES, INC.

Consult FASCO First!

ROCHESTER 2, NEW YORK

DETROIT OFFICE—12737 PURITAN—PHONE: UN 17476



You drive through the "EYES" of your springs

Built-in features of leaf springs are often overlooked and/or minimized.

The conventional automotive drive* propels all sprung weight through the "eyes" of the leaf springs. Leaf springs must be designed and built to take this terrific thrust of power, transmit it to the load, and distribute it throughout the framing. At the same time they must support, balance, and spring the weight of the body and the load.

This highly efficient performance of leaf springs is accomplished by built-in features and balance inherent in a three-point suspension at shackle, hanger, and axle.

Over FIFTY YEARS' experience in meeting the strictest specifications in the design and manufacture of leaf springs enables the Automotive Division of Detroit Steel Products Company to build leaf springs that perform perfectly on the job.

**Hotchkiss Drive*

You stop through the "EYES" of your springs

Leaf springs are required to balance, support, and spring the dead weight of load and body, while taking the full thrust of momentum, as the vehicle is braked to a stop.

Leaf springs perform all these important functions with UTMOST ECONOMY TO BOTH MANUFACTURER AND CUSTOMER. That's why *the makers of most of America's trucks use DSP Leaf Springs as original equipment.*

DSP Leaf SPRINGS

Automotive Division

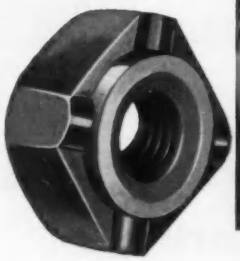
DETROIT STEEL PRODUCTS COMPANY

Also Makers of *Fenestra* Building Products

2250 E. Grand Blvd., Detroit 11, Michigan

SINCE 1904 — ORIGINAL EQUIPMENT ON CARS, TRUCKS, CABS, BUSES, TRAILERS

SPEED UP THE FABRICATING, FASTENING AND ASSEMBLING OF METAL PARTS WITH



MIDLAND
WELDING NUTS!

Midland Welding Nuts may be the answer to your dreams if you're in a business which fabricates, fastens, or assembles metal parts—OR, if you're a designer of products incorporating such parts.

Midland Welding Nuts are welded to the parts to be worked so that bolts can be turned into them speedily—without the need for any device to hold them in place.

They're just the ticket for those hard-to-get-at places. And they stay put—will not work loose or rattle.

Relied on by manufacturers the world over—and specified universally by product designers—Midland Welding Nuts will lower your assembly costs, speed up operations all along the line for you.

Write or phone for complete information!

The MIDLAND STEEL PRODUCTS COMPANY

6660 Mt. Elliott Avenue • Detroit 11, Michigan
Export Department: 38 Pearl St., New York, N. Y.
Manufacturers of
Automobile and Truck Frames • Air and Vacuum Power Brakes
Air and Electro-Pneumatic Door Controls

Applications Received

continued

Dayton Section

Joseph H. McNinch, Jr., Paul E. Wilkins

Detroit Section

A. F. Bauer, Howard C. Burns, Wu-Wai Chao, John W. Chung, Roger H. Compton, Curtis W. Copeland, Edward T. Cruty, Linn F. Cummings, Lloyd R. Enix, Carl E. Fredrickson, Robert J. Gorman, Raymond C. Haefner, Harlan L. Hanson, Ronald E. Herman, Frederick G. Howard, Jr., Albert A. Jadach, John J. Jakupco, Jr., William R. James, Gary B. Johnston, Harley G. McIntosh, Walter K. McPherson, Richard A. Mills, Thomas A. Munro, Allan F. Omerza, G. A. Panier, John J. Retich, Jr., Frederic G. Riebling, Erwin R. Schirs, Theodore W. Selby, John G. Spruhan, Hans R. Stauber, Lawrence W. Steiner, MacDonald S. Stuart, Gregory R. Taylor, Sydney W. Taylor, E. Joseph Whitcomb, Jr., Edward A. Zeschin, C. Raymond Zink, Jr.

Hawaii Section

Clifford Geis

Indiana Section

Guy V. Morgan

Kansas City Section

Jack P. Woods

Metropolitan Section

Charles E. Baugh, William F. Bland, Murray H. Edson, Richard F. Finn, Helmut H. Krapp, W. M. Langton, Robert K. McQuiston, Alexander H. Popkin, Myron M. Rosenthal, Caswell Speare

Mid-Continent Section

Joel L. Carson, Donald G. Perkins

Mid-Michigan Section

James F. Bourquin, Donald E. Dickson, Lenard F. Fink, Carlton W. Ogger, Raymond P. Ranta, Robert J. Schultz

Milwaukee Section

Jerome J. Ahne, Percy Clemans, Ralph F. Lofy, Arthur R. Long, Daniel F. McCormick, Louis F. C. Pike, Leo Schwass, Thomas L. Tannert, Robert E. Wenzel

Montreal Section

George A. Pethick, Max M. Richler

New England Section

Maurice Zabarsky

Northern California Section

Benjamin W. Dixon, Claude L. Fennema, Robert O. Lippi, Fred Stevens, Jack M. Vickland

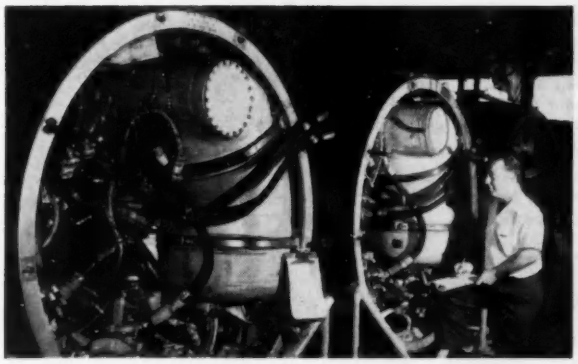
Aeroquip Hose and Reusable Fittings Cut Maintenance Costs for Eastern Air Lines

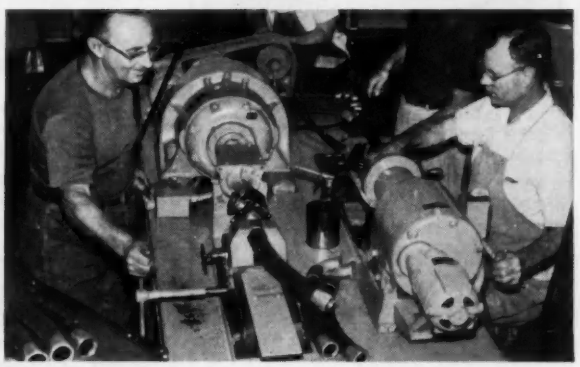
The periodic overhaul and inspection of each Eastern airliner includes removal and testing of every hose line. Aeroquip reusable fittings cut Eastern's replacement hose line costs, because the fittings can be used again and again. This Aeroquip advantage simplifies maintenance of military, corporate and private as well as commercial aircraft.

Right—In Eastern's Miami maintenance base, used hose lines are taken apart to salvage Aeroquip reusable fittings, which last indefinitely.

Lower Right—New hose lines, with both straight and elbow fittings, are assembled quickly by Eastern mechanics.

Below—Engine build-up foreman makes a final check of rebuilt engines. Every component has been rebuilt or replaced. Clamps on the oil tanks are made by Marman, an Aeroquip subsidiary.





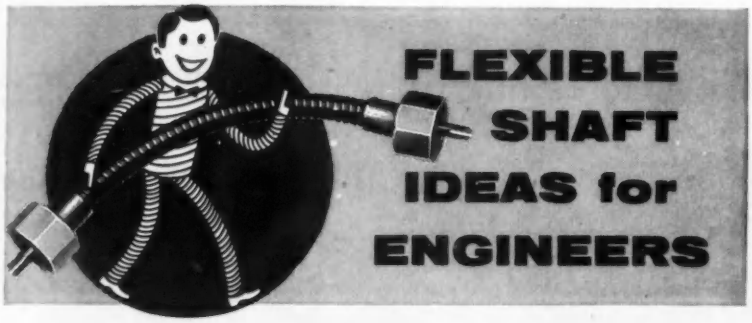
Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

IN CANADA: AEROQUIP (CANADA) LTD., TORONTO 15, ONTARIO

LOCAL REPRESENTATIVES IN PRINCIPAL CITIES IN U.S.A. AND ABROAD • AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

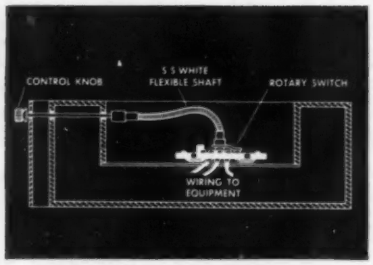


Flexible Shafts are the key to many remote control problems

Space, operating and servicing requirements are readily met with S. S. White Metal Muscles®

MANY kinds of equipment contain internal elements which require more or less frequent adjustment from the outside. This comes under the heading of remote control.

There are various ways by which remote control can be accomplished. The simplest, of course, is to mount the element requiring control on the inside of the equipment case or housing with its shaft extending through for manual or automatic operation.

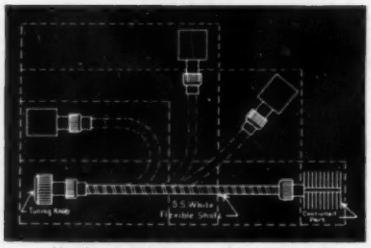


A flexible shaft used to control an inaccessible rotary switch. Note the 90° turn.

Flexible Shaft Simplicity

However, such direct connection is frequently not feasible. Factors of space, circuit efficiency, ease of assembly and of servicing must be considered. This applies also to the selection of the method of control to use.

An S.S.White Remote Control Flexible Shaft makes it possible to satisfy these requirements in an extremely simple manner. In place of comparatively complicated gearing, universal joints and similar contrivances, a single self-contained, easily applied flexible shaft does the trick.



Meeting varying space requirements is easy with a flexible shaft.

Design Freedom

But simplicity is only one advantage the flexible shaft offers for remote control. Perhaps its most valuable advantage is the freedom it gives the designer in locating the controlled element and its control knob or dial.

The flexible shaft permits the former to be placed wherever desirable to secure top equipment efficiency, ease of assembly, space saving and convenient servicing. At the same time it allows the control to be mounted in the most convenient operating position.

Another big advantage is the fact that it eliminates the need for accurate alignment of connected parts.

FLEXIBLE SHAFT DATA

Bulletin 5601 has concise information on how to select and apply flexible shafts. Send for a copy.

FS-1

S.S.White — FIRST NAME IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION, DEPT. J, 10 EAST 40th ST., NEW YORK 16, N.Y.
Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

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Foreign

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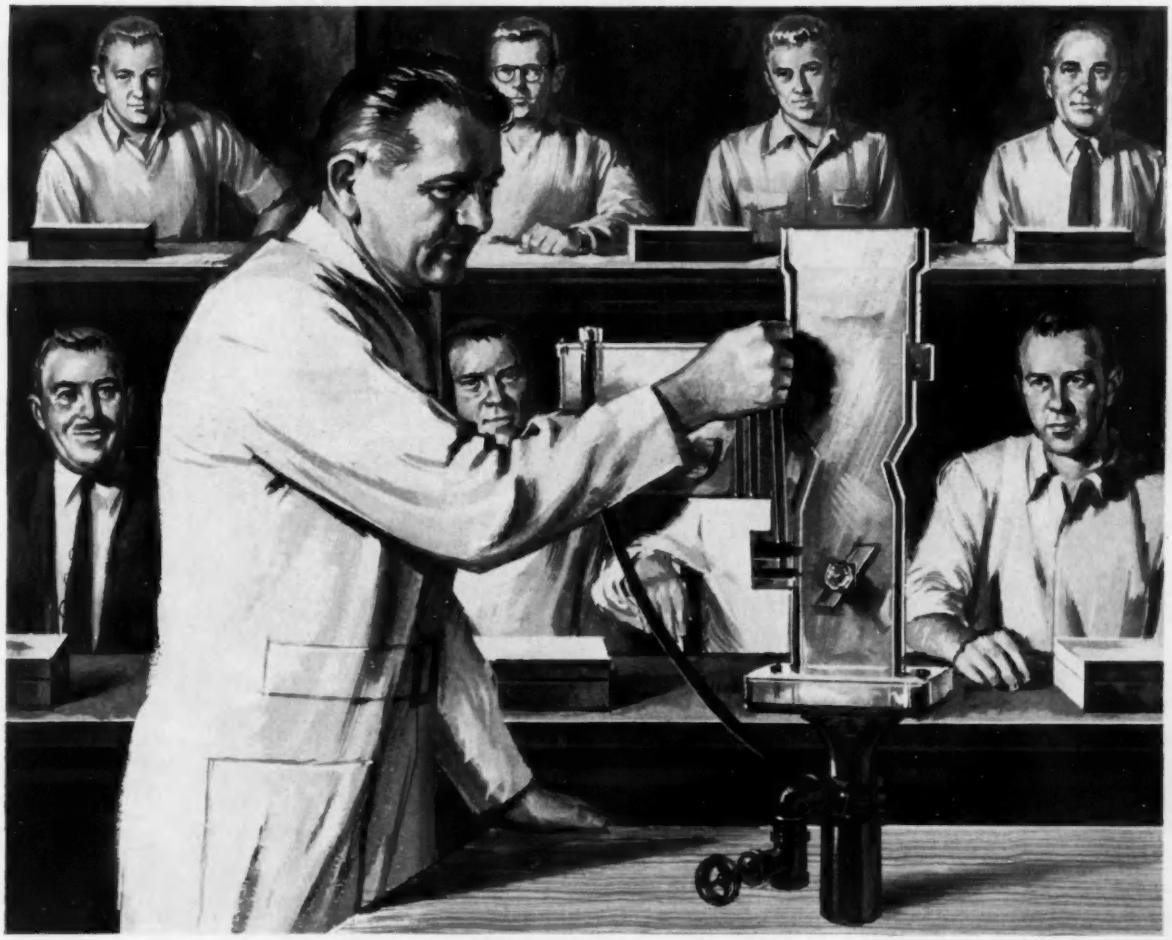
AT CARTER...



The Academy of Carburetion

No ivy-covered walls here . . . but it's one of the oldest specialized automotive service schools in existence. The Carter Factory Service School was founded in 1934 . . . dedicated to the purpose of helping Carter servicemen do better tune-up jobs. More than 5,000 "Masters of Recarburetion" have been graduated from the "Academy".

It's a stiff course . . . but worth it. Years of automotive know-how are crammed into three busy weeks. Lectures, plus learning by doing, are combined with the use of the most modern equipment. The classes are purposely kept small to allow plenty of individual instruction.

Why do we do it? Because we have learned how vitally important good fuel system performance is today. We have taken it upon ourselves not only to build the finest carbureters, fuel pumps and filters . . . but also to help keep them that way, for years of customer satisfaction.

CARTER CARBURETOR CORPORATION • **St. Louis 7, Missouri**

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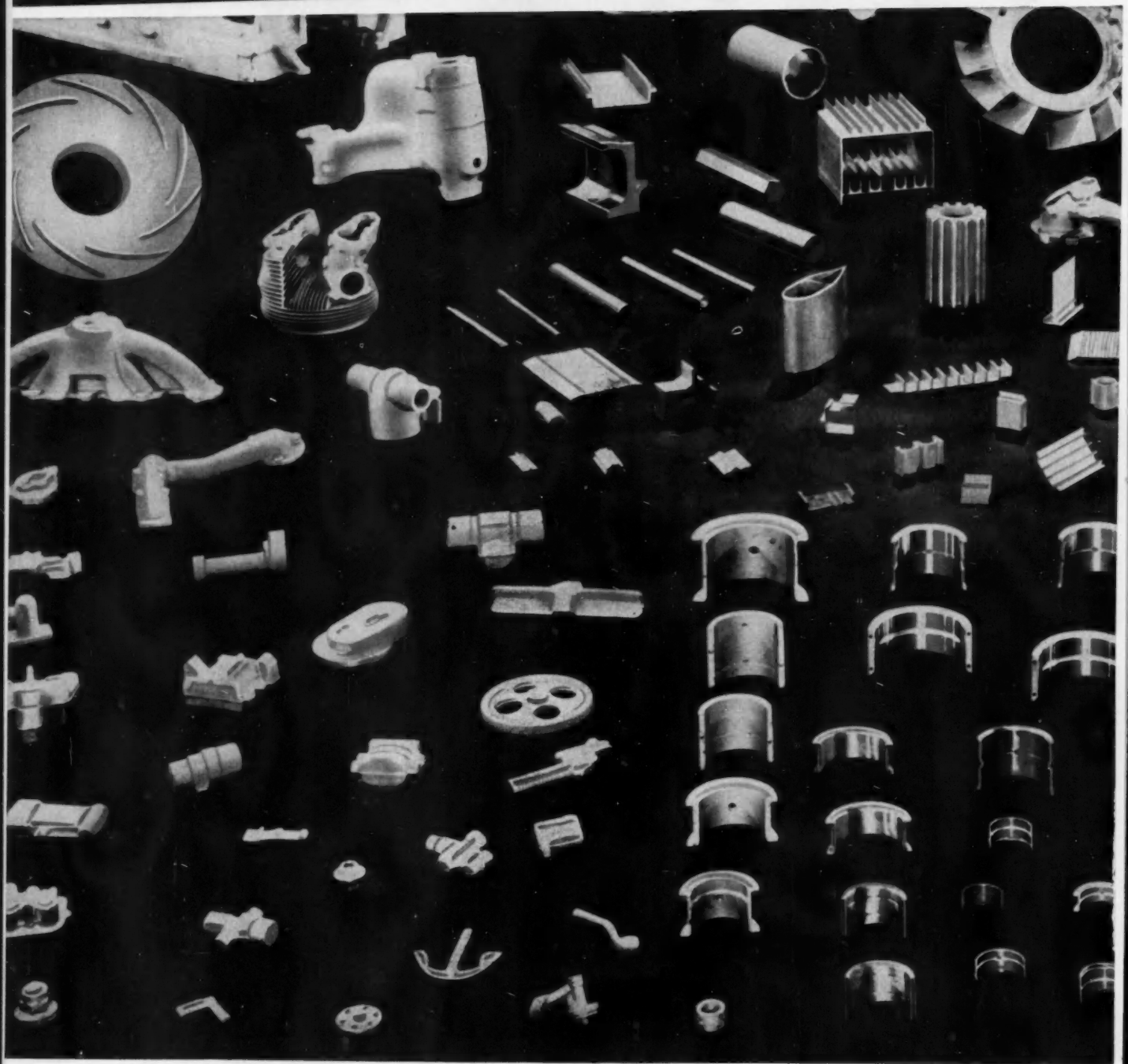

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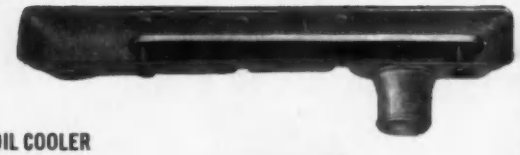
Installation of the most modern equipment, doubling our engineering and other specialized personnel are but some of the factors contributing to our newly increased productivity and efficiency.

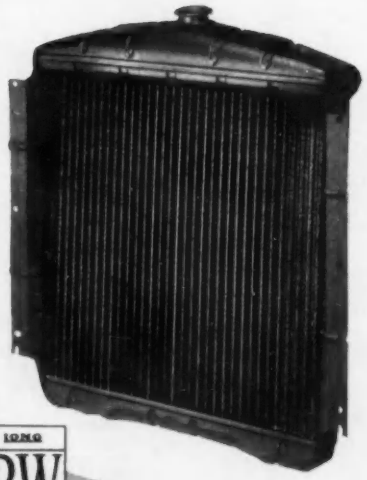
Long's experience in quality manufacture includes over a half century of volume production for American industry. The progressive policies of Borg-Warner—of which we are a Division—set new goals in expanding our engineering and production service.

We direct you to the advantages of meeting your cost and delivery requirements through recent developments and new applications of our products. We're eager to tell you about them in detail.



NEW LONG RADIATOR BOTTOM TANK OIL COOLER

Simply and economically placed in the lower tank of the radiator this new Long-designed oil cooler in one neat out-of-the-way package maintains desired oil temperature for engine and/or transmission. They are available in a variety of lengths, thicknesses and multiple wafers, and are now in volume production at Long.



LONG-BUILT RADIATORS

Long radiators make the most efficient use of material and provide a more rugged construction at competitive prices. Long's outstanding engineering facilities are available to you for design and building of any type of radiator or heat exchanger.

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LONG MANUFACTURING DIVISION, BORG-WARNER CORPORATION

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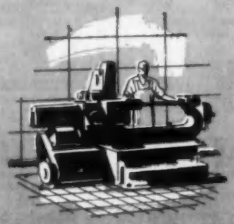
A complete line of Roller Bearings . . .

For every field of transportation and industry

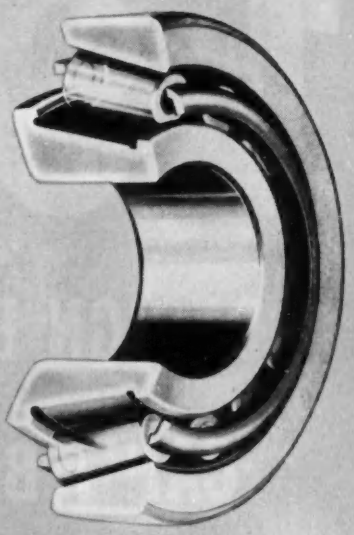


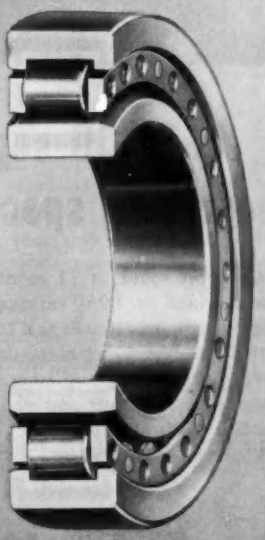
Job-tailored in a wide range of sizes to fit your specific needs

Aircraft? Automobiles? Earth-moving or farm equipment? *Whatever* you make, if your product uses straight or tapered roller bearings, Bower can meet your specifications *exactly*. For dependable Bower bearings are virtually custom-built to the job . . . engineered and sized to match any requirement.

Important, too, are exclusive Bower design features that assure long life, top performance, *less maintenance*. And when you specify Bower bearings you can always be certain of the highest quality materials and workmanship. These reasons, of course, are why Bower straight, tapered and journal roller bearings are used by leading manufacturers everywhere—for any application.

Let a Bower engineer give you full details of the complete Bower line. Call him in while your product is still in the design stage.





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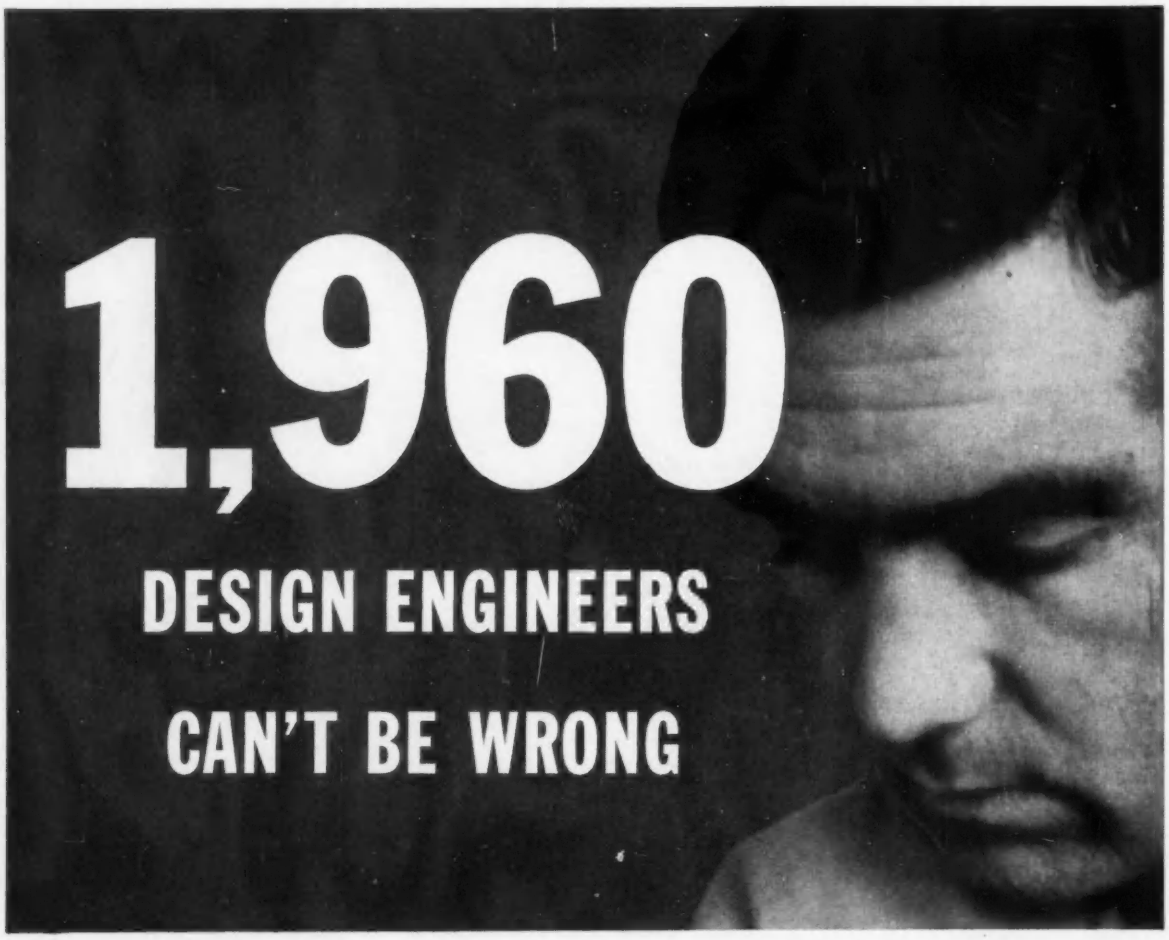

In 1,960 separate applications these men specified IPC packings

In the short space of 11 months, January-November 1955, IPC packings were specified for 1,960 varying applications. From a simple water pump to a highly complex retainer seal for an automatic transmission, IPC leather and synthetic packings met every design requirement!

IPC's engineering and laboratory staff analyzed all factors . . . carefully developed compounds and designed seals for each application. This is the attention to detail that ensures better packings . . . better performance.

Whatever your problem — specify IPC.

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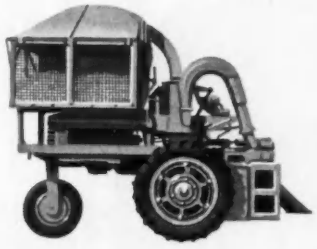
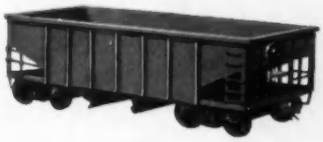
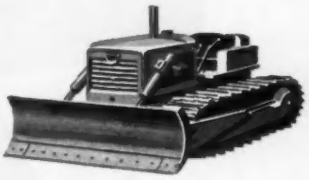
11. Bonded Case Seal Straight Lip Thin Rind Type
4. Bonded Washer Seal Limited Contact Lip
12. Bonded Case Seal Limited Contact Lip Thin Rind Type
5. Bonded Washer Seal Straight Lip With Garter Spring
13. Rubber Covered Bonded Case Seal Straight Lip
6. Bonded Washer Seal Limited Contact Lip With Garter Spring
14. Rubber Covered Bonded Case Seal Limited Contact Lip
7. Bonded Case Seal Straight Lip
15. Rubber Covered Bonded Case Seal Straight Lip With Garter Spring
8. Bonded Case Seal Limited Contact Lip
16. Rubber Covered Bonded Case Seal Limited Contact Lip With Garter Spring

P1







MAKE IT WEIGH LESS

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HIGH-TENSILE STEEL

MAKE IT LAST LONGER

You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

- It is 50% stronger than mild steel.
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- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
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- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel—it can be cold formed as readily into the most difficult shaped stamping.

When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel—long recognized specialists in flat-rolled steel products.

N-A-X Alloy Division

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. . . three different sealed beam headlamps
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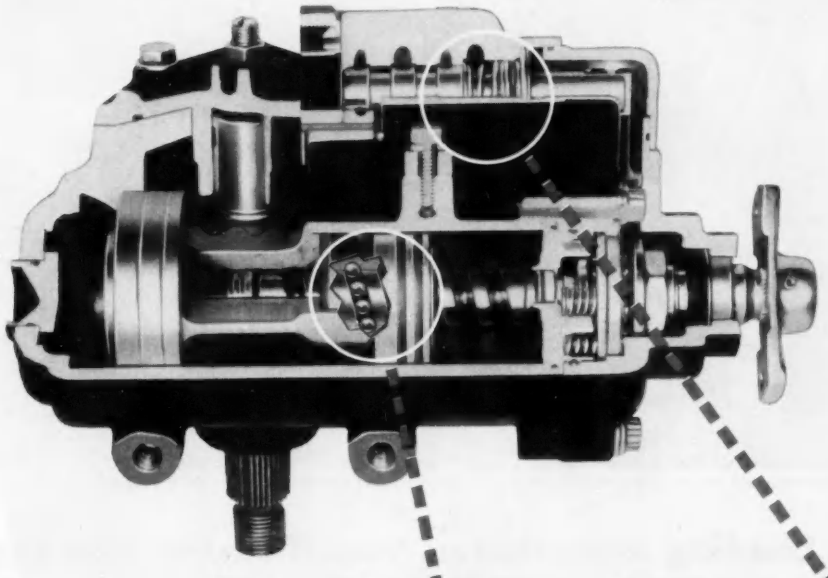
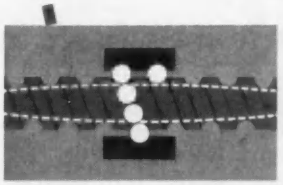
NEW 1956 SAGINAW POWER STEERING SYSTEM INTRODUCES TWO EXCLUSIVE ADVANCEMENTS

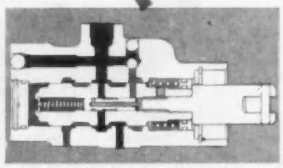


1 New "Parking Valve" automatically limits manual effort to 5 lbs.

With this compact, simplified "in-line" unit, Saginaw engineers have made parking almost *twice as easy* as with ordinary power steering. Saginaw's famed "feel of the road" is still provided by hydraulic reaction, which automatically keeps manual steering effort proportional to the turning resistance of the wheels on the road. During parking, however, the reaction pressure is restricted to 250 psi by this ingenious limiting valve, so steering effort never exceeds five pounds.



Exaggerated diagram of ball nut and steering worm, showing "plateau" in center of thread, which tapers toward each end. Preload keeps gear snug on center, while taper assures easy turning, fine returnability.



Magnified diagram of "parking" valve in center of hydraulic control valve. When reaction pressure reaches 250 psi, this limiting valve automatically shuts off oil supply, restricting manual effort to maximun of 5 lbs.

2 New Pre-Loaded Worm gives "Micrometer" control on highway

The new 1956 *Safety* Power Steering System helps to hold the car straight "on course" by means of this precision pre-load directly on center of the steering worm. This keeps the gear snug on center, providing extremely precise control on straightaways. There is much less tendency to "wander" in gusty crosswinds. This feature lets you drive *more relaxed*, without constant steering corrections—great on long trips!

New *Safety* Power Steering is standard equipment on all 1956 Cadillacs, Buick Roadmasters and Supers, and Oldsmobile Ninety-Eights; on all other 1956 Buicks, Oldsmobiles and Pontiacs (and linkage type on Chevrolet) optional at extra cost. Saginaw Steering Gear Div. of General Motors, Saginaw, Mich.

new Safety POWER STEERING by Saginaw

OVER 2½ MILLION SAFETY POWER STEERING SYSTEMS ARE NOW IN SERVICE

On the assembly line of a leading automotive manufacturer, workers are installing Johnson bearings in a popular six-cylinder engine.

Leading Automotive Manufacturer Depends On Johnson As A Supplier Of Bearings

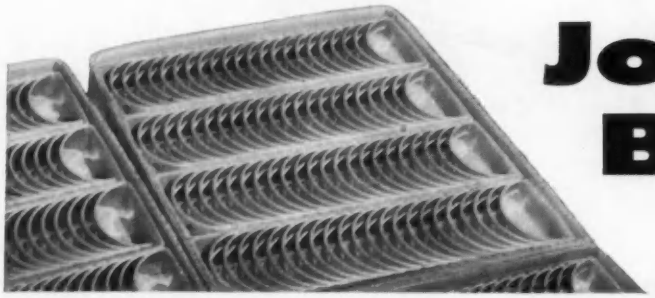
Here's Why: First, Johnson engineers, metallurgists, and production men devote all the time necessary to help solve problems in the design and production of engine bearings to meet demands for higher speeds and longer service.

Second, Johnson, as a leading supplier of original equipment bearings to automotive manufacturers, can be depended upon to meet exacting specifications bearing after bearing, order after order when it comes to tolerances, smooth, mirror-like finish, and chemical analysis of the various metals specified.

Third, Johnson has built a reputation for getting bearings delivered when and where they are wanted and in the type of packages ordered.

Fourth, Johnson's prices are competitive with other leading bearing manufacturers.

If you have a problem in the design of engine bearings, a Johnson man might have your answer. It won't cost anything to talk it over. Write, wire, or phone the Johnson Bronze Co., 610 S. Mill St., New Castle, Pa.



Johnson Bearings

The first comprehensive filtration guide ever edited specifically for designers.

Where are filters used? Why are filters used? How do filters save money? Now for the first time Purolator's new "Filtration Manual for Designers" has all the answers gathered together in one place.

Some typical section headings

- **space requirements**
- **filter costs**
- **selection of type of element**
- **deciding flow capacity needed**
- **economics of filtration**
- **how Micronic® and metal edge filters are made**

"Filtration Manual for Designers" spells out application considerations in detail including degree of filtration, flow rate, contamination to be removed, viscosity of fluid, plus a complete glossary of terms that apply to filtration. Printing of this manual is limited so please send in coupon for your copy today.

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Please send my copy of your "Filtration Manual for Designers." I'm enclosing 25¢ for postage and handling.

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Now...moisture-free air for air brake systems

New Wagner moisture ejection valve keeps reservoirs clean and dry—*automatically!*

Since moisture accumulation in the brake system can be a problem, you'll be interested in this fully automatic moisture ejection valve.

Operating at 15 to 20 p.s.i. pressure, it ejects moisture with each average brake application.

It mounts in any convenient location . . . no heating element is necessary as the valve cannot freeze in open (exhaust) position. It connects to the air system by two air lines—one leading from the bottom of the air reservoir and the other from a brake application line.

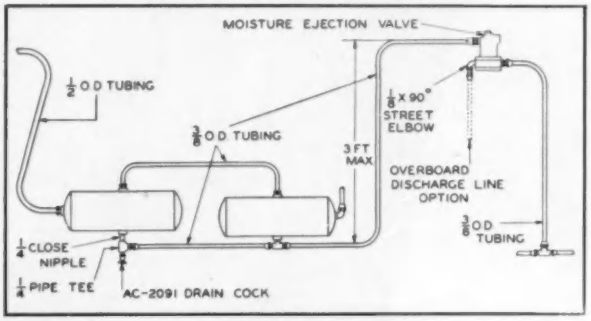
Expulsions occur without a noticeable drop in tank gauge pressure.

HIGH CAPACITY—valve can eject up to 4 fluid ounces at a time . . . even expels foreign particles which may have settled to the bottom of the tank.

CORROSION RESISTANT metal parts. Diaphragms are a combination of neoprene and nylon cord for long life and high resistance to oil.

OPEN TO ATMOSPHERE—valve fluid cavities are open to atmosphere . . . it is impossible to trap moisture within the unit. *Cannot balance in open position* . . . and "dump" reservoir pressure.

TYPICAL PIPING DIAGRAM



Wagner Air Brake Application Valves for Straight Air Systems

Actuating Arm Type — Treadle Type — Basic Type

These valves provide complete braking control for safe, sure stops. Each valve is completely interchangeable with other makes of valves. The basic valve can be installed by simply transferring the actuating mechanism to the Wagner valve. The treadle valve can be adjusted to angle properly with the contour of the floor board and also offers external adjustment of exhaust valve clearance.

For complete information on Wagner Air Brake Systems, write today for Catalog KU-201A.

K56-28

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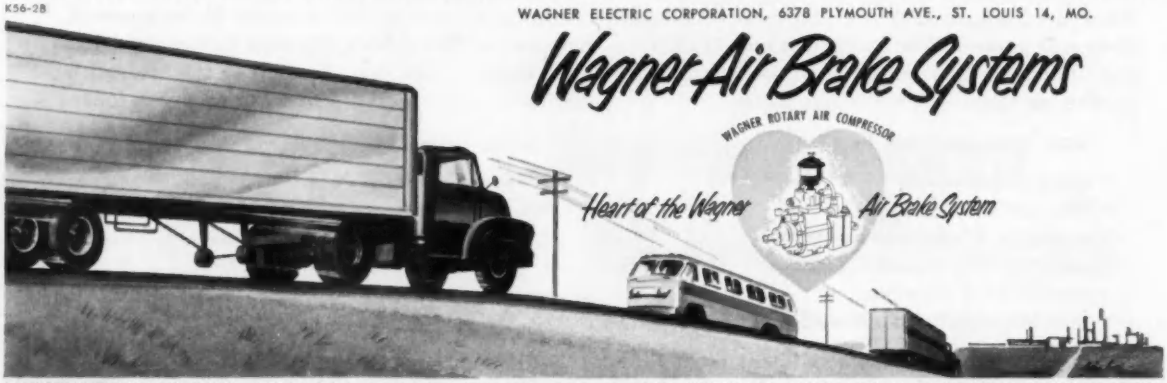

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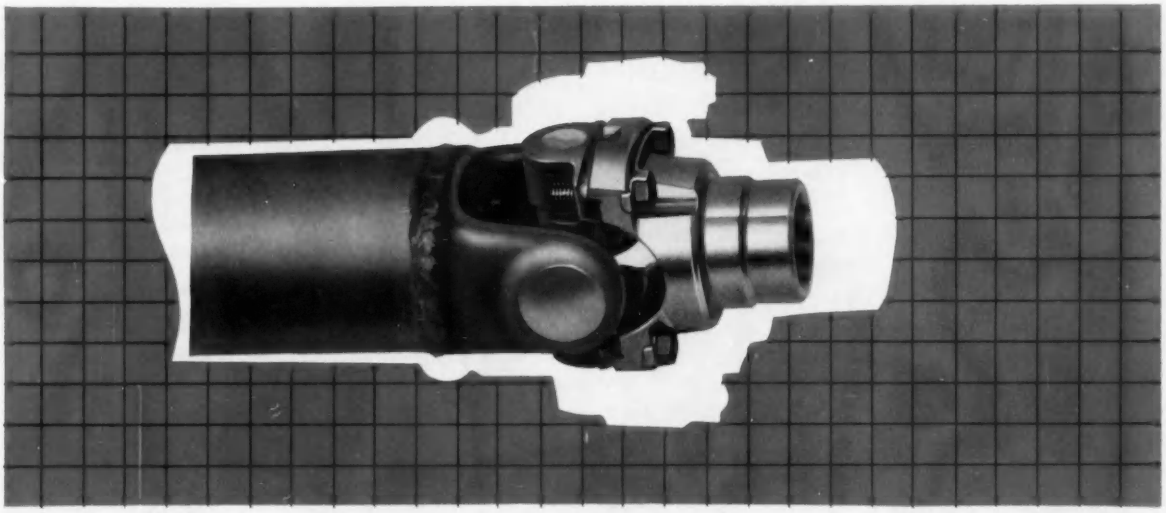
FOUR WAYS BETTER



1. **STRONGER**—2500 lbs. Ft. static torque. This NEW joint is stronger than any previous automobile joint of comparable size.

2. **SMALLER**—3-9/16″ swing diameter. This NEW joint requires less clearance, making possible more compact design.

3. **LIGHTER**—This NEW joint weighs 20% less than previous joints having the same torque capacity.

4. **EASIER TO INSTALL**—This NEW joint saves time and money on the assembly line because it has less parts to handle.

Give your next car the benefit of the 4 advantages provided by this NEW joint development. Let MECHANICS engineers help you design power transmission lines better suited to the low floor board, more powerful engine and higher speed requirements of your future models. Send print and specifications—for their prompt recommendations.

MECHANICS UNIVERSAL JOINT DIVISION

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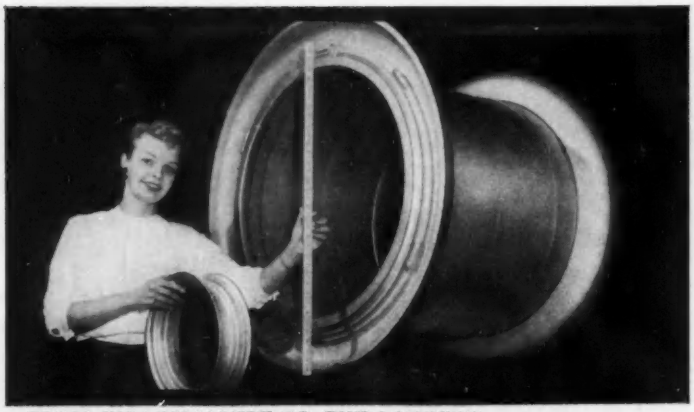
World's most com

Goodyear stores rims in outdoor areas, and so can you—thanks to exclusive Goodyear Bond-a-Coat finish which provides long-lasting resistance to rust and corrosion. Bond-a-Coat has been used and proved on Goodyear Rims for ten years.



FROM THE SMALLEST TO THE LARGEST — THERE'S A GOODYEAR RIM TO FIT YOUR NEEDS

Truck, Bus and Trailer Rims must best this test. Rim and wheel assemblies travel the equivalent of 750,000 miles in 30 days on this unique apparatus. It's a testing drum on which obstacles, mounted at intervals, simulate severest road conditions. Only when a Goodyear rim passes tests like these is it ready to be manufactured in quantity.

TIRE MANUFACTURER COMES THE

plete line of rims

YOU'D naturally expect the world's tire-building leader to be first through the years in the advancement of tire-mounting techniques.

So from Goodyear's huge research and testing facilities has come a never-ending parade of rim improvements—culminating in a complete line of rims for tubeless tires – including the Tru-Seal Rim, which makes tubeless tires practical for even the largest vehicles used today.

What does this notable record of achievement mean to you? Just this.

Whatever your rim requirements, you'll find the answer emerging from Goodyear's modern steel fabricating plant.

This busy plant turns out rims for every type of vehicle, from the smallest truck to the largest earth-mover—for every imaginable farm and industrial use. These rims range in weight from 8 pounds to over half a ton.

And each type is subjected to the most grueling tests of quality and endurance before being approved or recommended.

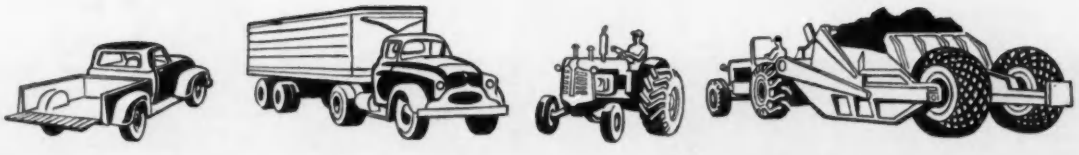
So it's not surprising that more tons are carried on Goodyear rims than on any other kind. Why not take advantage of this vast Goodyear experience when solving your rim problems. The G.R.E. (Goodyear Rim Engineer) will help you select the type and size of rim best suited to your needs. Write him at Goodyear, Metal Products Division, Akron 16, Ohio, or contact your local Goodyear Rim Distributor.

Buy and Specify

GOODYEAR

Tru-Seal—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

MORE TONS ARE CARRIED ON GOODYEAR RIMS THAN ON ANY OTHER KIND



We think you'll like "THE GREATEST STORY EVER TOLD"—every Sunday—ABC Radio Network—THE GOODYEAR TELEVISION PLAYHOUSE—every other Sunday—NBC TV Network

Mayari R makes it lighter... stronger... longer lasting

How Miller Trailers gain extra strength without extra weight

Down in Bradenton, Florida, the plant of Miller Trailers, Inc., turns out a variety of trailers large and small. As all good vehicles should, Miller trailers cater to profitable operation by combining lightest feasible weight with top-most payload capacity.

To achieve this desirable combination, Miller engineers employ Mayari R high-strength, low-alloy steel at critical points in the trailer design. Because Mayari R's yield point is 50 pct higher than that of structural carbon steel, substantially increased strength and carrying capacity are built into such members as the upper-fifth-wheel spider and the spring suspension rail, without increasing the thickness of the steel.

Automotive vehicle designers and operators can benefit in a number of ways by taking advantage of the superior properties of Mayari R. Strength alone is usually reason enough to choose this versatile steel. But Mayari R also offers 5 to 6 times more resistance to atmospheric corrosion than carbon steel, and holds paint up to 80 pct longer, depending on the type of paint used.

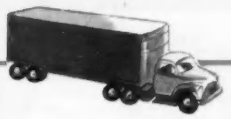
Shop men find they can weld and work Mayari R about as readily as other materials, and by the same general procedures. Operators appreciate Mayari R's ability to resist abrasion, impact and vibration. The Mayari R story is fully described and illustrated in Catalog 353, a copy of which can be yours on request to our nearest office.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

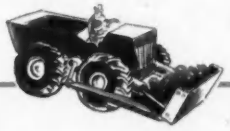
BETHLEHEM STEEL

ON
Highway



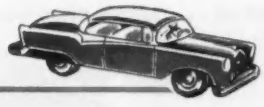
ON
Farm

IN
Industry



ON
Water

IN
Transportation



Gemmer

STEERING
POWER

For 49 years Gemmer has been steering powered vehicles

GEMMER
Steering

GEMMER MANUFACTURING COMPANY
DETROIT, MICHIGAN

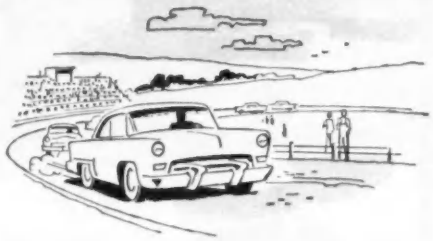
WE WERE

in every recent major automotive

Spicer Products were there...helping

Mexican Road Race

1954—Lincoln, 1st and 2nd places.
1953—Lincoln, 1st, 2nd, 3rd, 4th, 7th, 8th and 9th places.
1952—Lincoln, 1st, 2nd, 3rd and 4th places.



Stock Car Races

1955—30 races won by Chevrolet,
5 races won by Ford Thunderbird.
1954—24 races won by Hudson Hornet.
1953—47 races won by Hudson Hornet.

Mobilgas Economy Run

1955 Sweepstakes Winner—Studebaker.
1954 Sweepstakes Winner—Studebaker.
1953 Sweepstakes Winner—Ford 6.
1952 Sweepstakes Winner—Mercury.

Since 1904 . . . when Clarence W. Spicer adapted the first universal joint to automotive needs . . . Spicer Products have helped set many new performance records, and have helped establish new standards of motor vehicle value in America's greatest industry.

In each new model year, original Spicer designs or cooperative developments serve to increase power transmission efficiency, through engineering excellence and quality of manufacture.

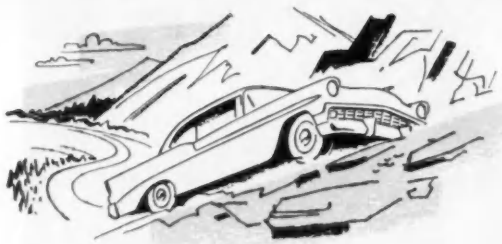
No matter what type of automotive vehicle you make . . . no matter what type of power transmission design you need . . . Spicer engineers and Dana resources can serve you well.

Spicer

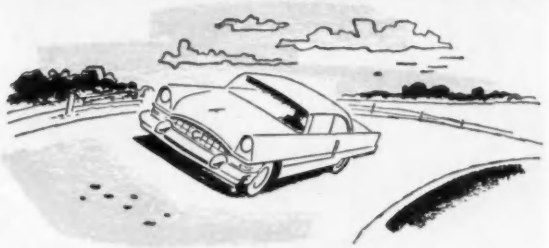
DANA CORPORATION Toledo 1, Ohio

THERE !

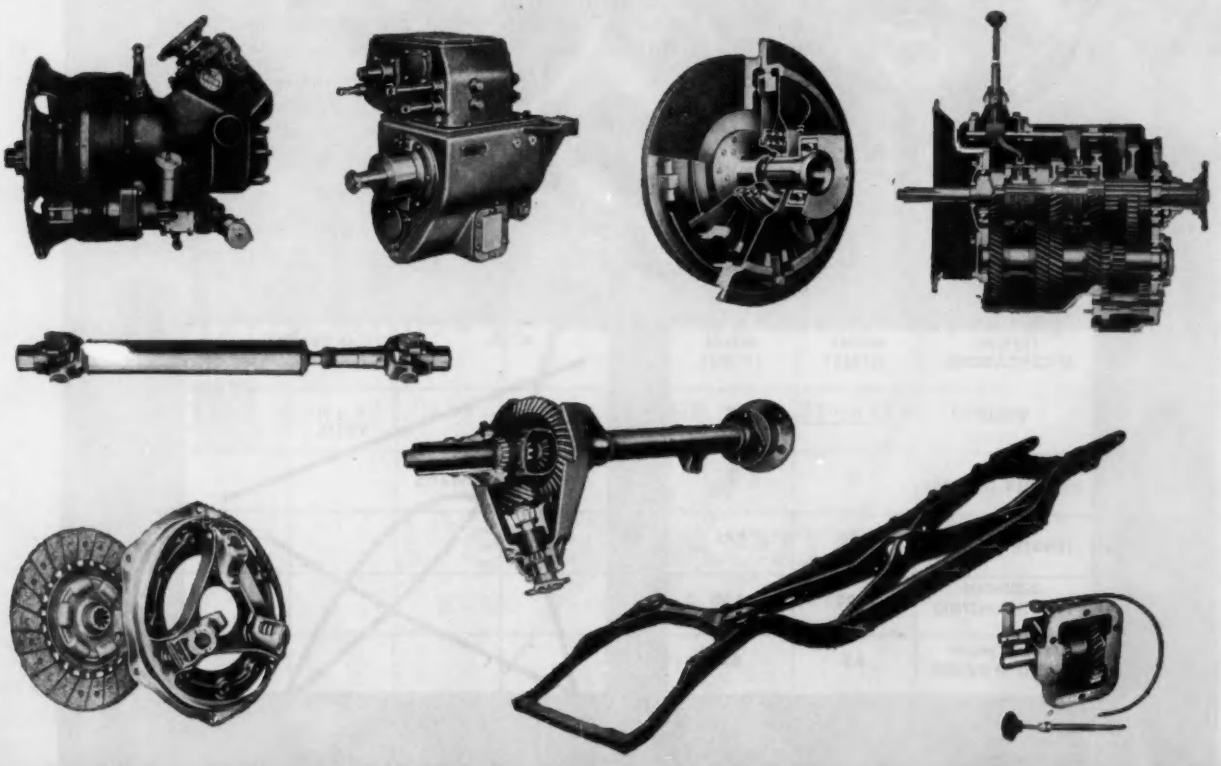
endurance, speed and economy test... to establish new world's records!



Pike's Peak Climb
New world record set September 9, 1955, by Zora Arkus-Duntov driving a 1956 Chevrolet. Time 17 minutes, 24.05 seconds.



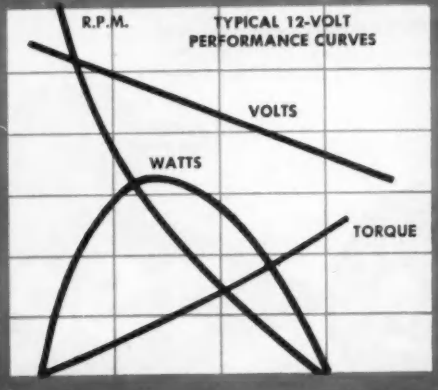
Durability Run
25,000-Mile Durability Run in 238.77 hours total elapsed time for an average speed of 104.7 MPH established by a Packard Patrician.



SPICER PRODUCTS: TRANSMISSIONS • UNIVERSAL JOINTS • PROPELLER SHAFTS • AXLES • TORQUE CONVERTERS • GEAR BOXES • POWER TAKE-OFFS POWER TAKE-OFF JOINTS • RAIL CAR DRIVES • RAILWAY GENERATOR DRIVES • STAMPINGS • SPICER and AUBURN CLUTCHES • PARISH FRAMES • SPICER FRAMES

PROGRESSIVE ENGINEERING MAKES THE DIFFERENCE

TYPICAL SPECIFICATIONS	MODEL 1113501	MODEL 1113551
VOLTS	6	12
FRAME DIAMETER (INCHES)	3	3
FRAME LENGTH (INCHES)	4.30	4.42
MOUNTED LENGTH (INCHES)	5.25	5.37
APPROXIMATE WEIGHT (POUNDS)	6.5	6.5



DELCO-REMY DEVELOPS A NEW LINE OF CRANKING MOTORS FOR OUTBOARDS AND OTHER APPLICATIONS

A new series of Delco-Remy cranking motors, with many new design features, is now available for outboards, garden tractors, power mowers and other similar applications.

With a frame diameter of only 3 inches, an overall length of slightly over 5 inches when mounted, and a weight of about 6½ pounds, the powerful new motors will crank one-cylinder engines up to 15 H.P., two-cylinder engines up to 35 H.P., and four-cylinder engines of even higher horsepower.

These four-pole, four-field motors, designed for both 6-volt and 12-volt systems, may be powered by standard Delco batteries.

Available now for original equipment applications, the new motors can be supplied with or without automatic drives and solenoid switches to meet varying requirements. They are yet another example of Delco-Remy leadership in electrical equipment "Wherever Wheels Turn or Propellers Spin." Manufacturers of engines and power equipment are invited to write directly to Delco-Remy for complete information and engineering assistance on the application of these units.

DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, INDIANA

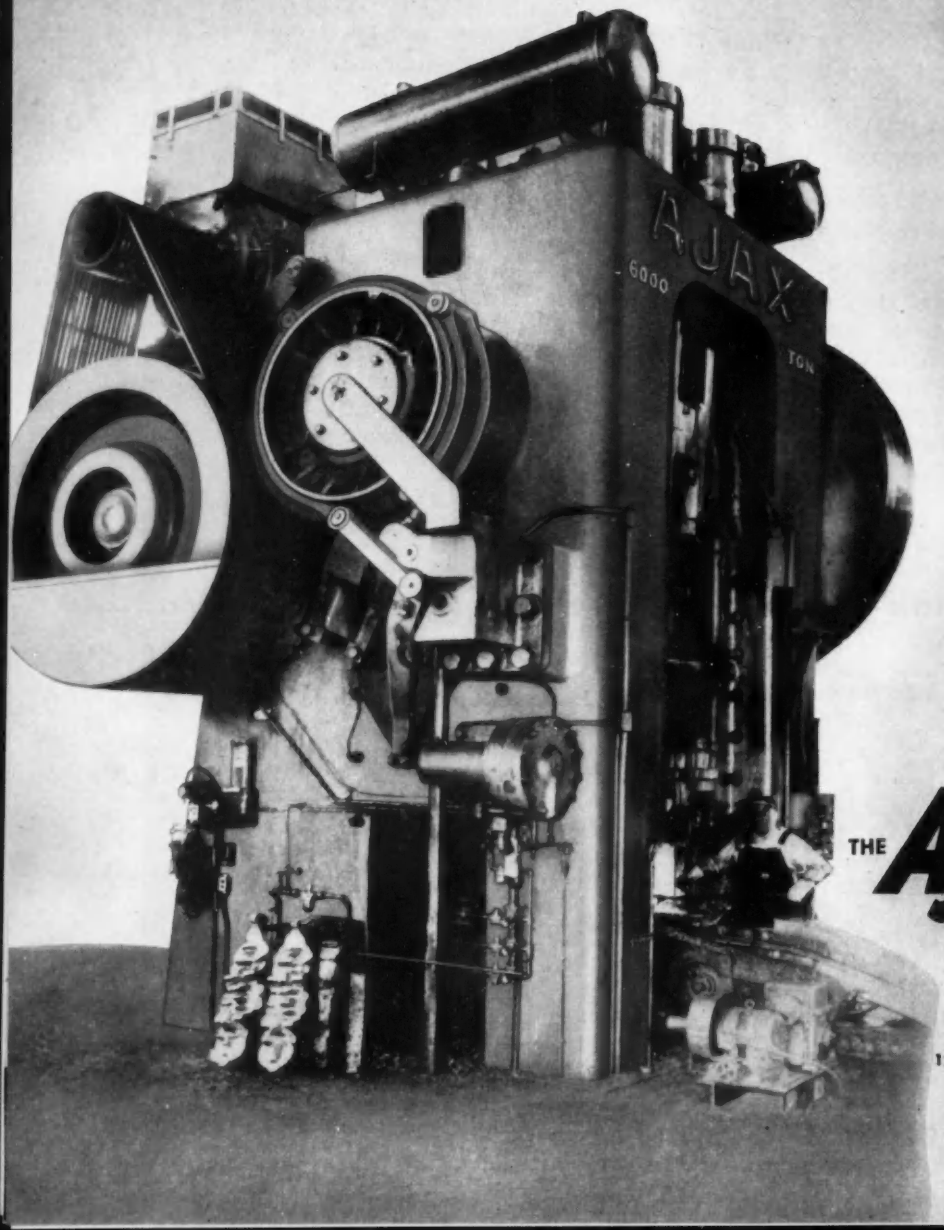
GM GENERAL MOTORS

GENERAL MOTORS LEADS THE WAY STARTING WITH

Delco-Remy

ELECTRICAL SYSTEMS

High Production of Automobile Crankshaft Forgings on AJAX *High Speed* Forging Presses



Production More than Doubled Over Former Methods on 6000 Ton Ajax Forging Presses

Crankshafts With Less Draft on Counterweights for Lower Machining Costs

For Your Forging Needs . . . Ajax Forging Presses Sizes 300 Ton to 8000 Ton

THE **Ajax** MANUFACTURING COMPANY

CLEVELAND 17, OHIO

110 S. DEARBORN ST., CHICAGO, ILL.

W. P. WOOLDRIDGE CO.

1209 BURLINGAME AVE., BURLINGAME, CAL.
6440 FLEET ST., LOS ANGELES 22, CAL.

Write for Bulletin 75 C

Now PARACRIL controls the "power" in power steering!

The "power" ***is oil.*** Keeping it in its place and working for you *can* be difficult. *Unless,* as one major manufacturer discovered, you put oil-resistant **PARACRIL®** on the job.

"O" rings made of this versatile chemical rubber are...

- completely impervious to hydraulic oils
- molded to close tolerances...non-swelling and non-shrinking to retain their close fit indefinitely
- *flexible* enough to seal at low pressures...*tough* enough to seal at extremely high pressures
- functional over a wide temperature range
- resistant to abrasion from metal parts in contact with them.

In brief, these Paracril "O" rings are *leakproof* and *lasting!*

And Paracril has proved its superiority in *hundreds* of similar applications. In automatic transmissions and other power units, in hydraulic hose, oil field equipment, and wherever oil, temperature, or friction raises a problem, Paracril supplies the answer.

Available in varying grades of oil resistance, in bale or crumb form, Paracril may be blended with other rubbers or resins, used wherever a rubberlike material is needed.

If you're not already familiar with the *many* advantages Paracril offers *you,* simply write on your letterhead to the address below.

SEE – Naugatuck Chemical Division, United States Rubber Company, at work on NBC's "Color Spread" TV spectacular, Sunday, March 25, 7:30 PM, EST.

NAUGATUCK

Division of United States Rubber Company
Naugatuck, Connecticut

US RUBBER

IN CANADA: NAUGATUCK CHEMICALS DIVISION • Dominion Rubber Company, Limited, Elmira, Ontario
RUBBER CHEMICALS • SYNTHETIC RUBBER • PLASTICS • AGRICULTURAL CHEMICALS • RECLAIMED RUBBER • LATICES • Cable Address: Rubexport, N.Y.

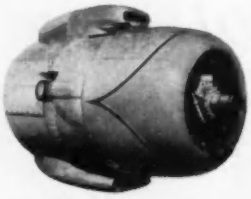
ROHR

IS THE WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POWER PACKAGES FOR AIRPLANES

but that's only part of the Rohr Story

ROHR has won fame for becoming the world's largest producer of ready-to-install power packages for airplanes like the all-jet Boeing B-52, the Douglas DC-7 and other great military and commercial planes.

But the whole ROHR story is in millions of parts, for in addition to power packages ROHR builds over 30,000 other different parts for aircraft of all kinds.



When you want aircraft parts better, faster, cheaper . . . call on ROHR and the ROHR engineering skill and production know-how gained from building thousands of power packages—and millions of other aircraft parts.

ROHR
AIRCRAFT CORPORATION

CHULA VISTA AND RIVERSIDE CALIFORNIA

Match the good reputation of your trucks with the AIR BRAKES your best customers prefer—BENDIX-WESTINGHOUSE!

MR. J. A. RYDER
President, Great Southern Trucking Company

Mr. Ryder, a veteran fleet operator with over 20 years' experience in the trucking business, directs his company's vast resources from executive headquarters in Jacksonville, Florida. Maintaining 62 modern terminals and call stations, employing 2000 people and operating 1,600 pieces of mobile equipment, Great Southern, in 1954, ranked 4 as the largest motor carrier operating within the six southeastern states of Florida, Georgia, South Carolina, North Carolina, Alabama and Tennessee. Mr. Ryder states . . .

"In our 20 years in business

We've bought 2,360 trucks

AND WHEN IT COMES TO AIR BRAKES, WE PREFER

Bendix-Westinghouse!"

THE WORLD'S MOST TRIED AND TRUSTED AIR BRAKES

MR. FRANK G. CAMPBELL
President, Campbell Sixty-Six Express, Inc.

From general headquarters in Springfield, Missouri, Mr. Campbell, since 1926, has directed the activities of this pioneer motor carrier in providing shippers with fast, dependable service from the Great Lakes to the Gulf of Mexico. Serving the nine states of Missouri, Illinois, Kansas, Oklahoma, Arkansas, Tennessee, Mississippi, Alabama and Louisiana, the vast Campbell Sixty-Six fleet rolls up mileage equivalent to twice around the world each day! Mr. Campbell says . . .

"In our 28 years of business

We've bought 1,000 trucks

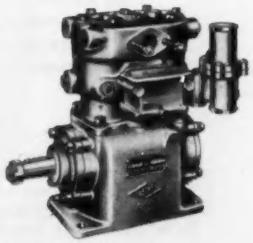
AND WHEN IT COMES TO AIR BRAKES, WE PREFER

Bendix-Westinghouse!"

THE WORLD'S MOST TRIED AND TRUSTED AIR BRAKES

It is a rarity, indeed, when a product in any field demonstrates customer preference so strong that it continually *outsells all other competition combined* year after year. Yet, for the past twenty-five years this has been the remarkable accomplishment of Bendix-Westinghouse Air Brakes in the truck and bus fields! In fact, recognition of the greater safety, economy and dependability of Bendix-Westinghouse Air Brakes by truck buyers has resulted in their factory installation on more and more truck models of all sizes.

Chances are good that your trucks, too, offer the many advantages of these powerful brakes. If not, we suggest you take advantage of the proven preference and superiority of Bendix-Westinghouse Air Brakes by offering them as factory-installed equipment. It's one sure and easy way to add more sales appeal to your vehicles!

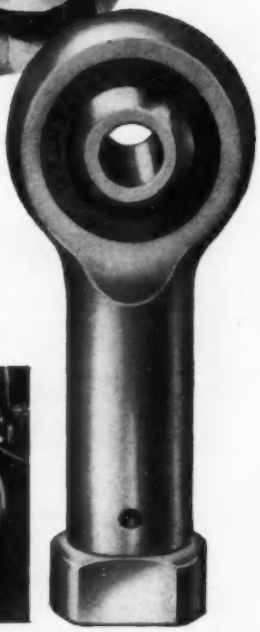


Over 1,500,000 compressors produced over a twenty-five-year span stand behind the TU-FLO 400. Many advanced features guarantee performance no other compressor can equal.

Bendix-Westinghouse BENDIX-WESTINGHOUSE AIR BRAKES REG. U.S. PAT. OFF. **AIR BRAKES**

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE COMPANY • General offices and factory—Elyria, Ohio. Branches—Berkeley, Calif. and Oklahoma City, Okla.

automation *with* HEIM *Unibal*



America's greatest participant sport, tenpin bowling, is played by approximately 20 million Americans on more than 60,000 alleys. The AMF Automatic Pinspotter represents a piece of equipment which all bowling for years has hoped would eventually be developed. It is a fully automatic unit for setting tenpins, returning the ball, accomplishing all pit services now done by hand, but with greater efficiency. More than 5,000 Pinspotters are now in operation.

In the AMF Pinspotter, Heim Unibal Rod Ends are used on the Pantograph bars which guide and stabilize the spotting table during its cycle of up and down drive. They are also used to drive the sweep mechanism and on the sweep carriage. The major application of the Heim Rod Ends on the Pinspotter is where it is employed in a shock-absorbing link arrangement to raise and lower the table. Here it is subjected to lifting a load of approximately 350 pounds.

THE ABILITY OF THIS JOINT TO COMPENSATE FOR MISALIGNMENT AND MAINTAIN FREEDOM OF ROTATION MAKES ITS USE ON THE PINSPOTTER VERY SATISFACTORY

The HEIM Unibal is the original Spherical Bearing developed, engineered, and manufactured by The Heim Company for nearly fifteen years. It consists of a single ball (instead of a single or double row of balls) rotating in an outer member, and supported by bronze bearing inserts which act as the race.

For center shaft or end support, the outer member is cylindrical in shape and made in a wide range of sizes. As a rod end for the transmission of power or motion at varying angles, the outer member is made with lubrication groove, in either male or female design, and with lubricator fitting if required.

SEE THE NEW HEIM CATALOG FOR COMPLETE LIST OF SIZES

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

These EXTRA properties make tough forming jobs easy!

HUNTER-DOUGLAS *Pre-painted* ALUMINUM STRIP

Mill quantities available in several aluminum alloys and tempers; wide color range.

UNUSUAL FORMABILITY—Hunter-Douglas coatings are specially compounded for high flexibility, freedom from cracking, chipping or peeling. The pre-painted strip readily roll forms, embosses, stamps... surface coating even stretches sufficiently to permit *deep drawing* without damage.

GOOD EXTERIOR DURABILITY—Finishes are remarkably colorfast in sunlight, resistant to heat and cold and successfully pass 500 hour, 90°, 20% salt spray test with no sign of lifting or blistering.

DOUBLE COATING, with each coat baked, produces a hard, bright, and completely opaque finish with excellent adhesion and resistance to scratching.

COLORS—Available in a wide range of decorative colors with excellent color reproduction.

WIDTHS—Up to 8" maximum and in nominal thicknesses.

For applications subject to severe weather exposure or exceptional forming stresses, for unusual beauty without need for subsequent painting specify Hunter-Douglas Pre-Painted Aluminum Strip... costs a little more, saves a lot!

HAT SECTION roll formed without cracking painted surface. No scratching despite considerable wiping action of multi-diametered rolls.

BOTTOM RAIL FOR VENETIAN BLIND. Unusual flexibility of finish permits roll forming and double lock seaming without breaking painted surface.

KNEE BRACE STRUCTURAL COMPONENT scored for knockouts, then formed to rectangular section without lifting finish. Knockout plugs practically invisible in pre-painted material.

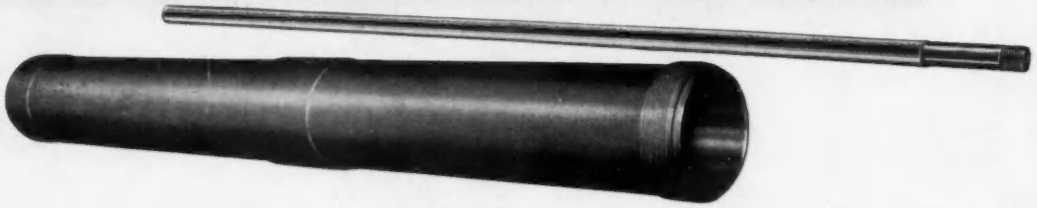
STRINGER blanked from pre-painted strip. Paint adheres tightly to extreme edges. No flaking or lifting to mar finish.

***Hunter Douglas* Aluminum Corporation**

HUNTER-DOUGLAS ALUMINUM CORPORATION, DEPT SA-2 • RIVERSIDE, CALIFORNIA • TELEPHONE OVerland 3-3030

MICROHONING*...

Efficient Stock Removal
with
LOW-VELOCITY ABRADING



INCREASINGLY, process engineers are recognizing Microhoning's low-velocity abrading technique as a means of combining efficient stock removal with precision.

The Brooklyn Works of American Machine & Foundry Company, in the precision-manufacture of recoil mechanisms for artillery weapons, required a process that would most efficiently remove substantial amounts of stock and generate functional surface characteristics on the I.D. of recoil cylinders and O.D. of piston rods. After extensive study of available methods, AMF selected Microhoning as the most productive and economical process for obtaining desired results.

The floating piston in the recoil cylinder has nitrogen gas on one side and hydraulic oil on the other. Because silver ring seals are used, any error in geometry or roughness of cylinder or rod surfaces will induce deformation or scoring of silver rings and break these important seals.

The largest cylinder processed by AMF to date is for a 75 mm gun and has a bore diameter of 4.750 inches and a length of 46 inches. Piston rods for this gun are 1.375 inches in diameter and 56 inches long. Both I.D. and O.D. operations are on the same Microhoning machine—Model 450 Hydrohoner.

The Microhoning process efficiently removes up to .026 inch of stock from cylinders and .006 inch from rods to correct waviness, taper and out-of-roundness. A geometric tolerance of .0001 inch is held while obtaining a 1.5 microinch finish.

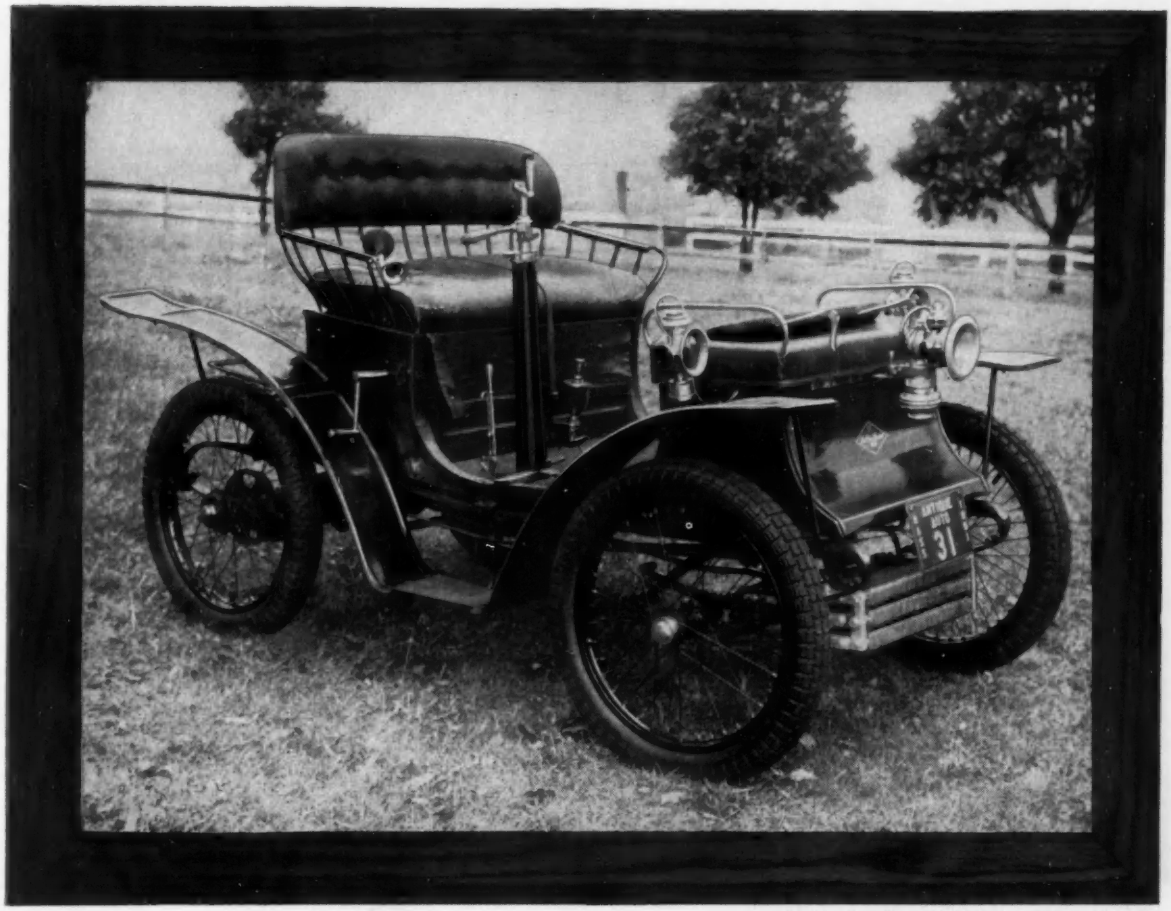
Working closely with AMF manufacturing personnel, Micromatic developed fixtures and tooling that minimize changeover time. The fixture for the cylinder is mounted on an indexing table so it is simply indexed away from the spindle while the rod is being Microhoned. You, too, can solve your precision stock-removal problems through application of Microhoning—the low-velocity abrading process.

For further information write for CROSS-HATCH, Vol. 7 No. 5

***MICROHONING=**
Stock Removal + Geometry + Size Control + Surface Finish

MICROMATIC HONE CORPORATION

8100 SCHOOLCRAFT AVENUE • DETROIT 38, MICHIGAN



Send for Free Print—1900 De Dion-Bouton Motorette.
This print from the file of P. S. de Beaumont, not for commercial use.

The De Dion-Bouton is remembered today for the De Dion axle, a frame that contained the differential, which more recently many racing and sports car models have adopted. This model also employed a one-cylinder engine mounted in the rear with automatic intake valve. This is one of a series of antique automobile prints that will appear in future Morse advertisements. Write for your free copy, suitable for framing, to: MorseChainCompany,Ithaca,NewYork.

Why Morse Timing Chains are original equipment on 18 out of 22 automobiles

Morse Timing Chain Drives are now specified as original equipment on eighteen out of twenty-two makes of automobiles. This is true for several reasons:

(1) Morse Timing Chain Drives assure car, bus, and truck manufacturers of long, trouble-free service life—eliminate maintenance difficulties. (2) Morse Timing Chain Drives offer safe, quiet, and smooth operation, even when camshafts and crankshafts are not exactly parallel. (3) Speedy delivery of a complete line of timing chain drives helps to meet production schedules. (4) Morse offers expert engineering service to assist in solving automotive timing chain problems of design, development, and application.

Check with Morse on your timing chain problems. Find out, too, how well other Morse Power Transmission Products can answer your needs in product design and application. MORSE CHAIN COMPANY, ITHACA, NEW YORK.

MORSE BW **CHAINS, CLUTCHES, AND COUPLINGS**

"WOW! what happened to our labor cost on this run?"

How many times—and how recently—have you asked this question? It's a good one, with a lot of possible answers. The important thing is, can these skyrocketing costs happen again, or have the causes been corrected? Often the answer is very simple—and easily remedied.

Could this be your answer?

A batch of castings or forgings with cracks that nobody found until costly hours had been wasted machining and finishing them . . . a heat treat that went sour . . . improper grinding, handling, cleaning, all are possibilities, and all can vary from run to run.

Cracks, whatever the cause, run up your labor costs if you don't find them *early* enough. Early enough to find and correct the cause before parts are run and finished in quantity, only to be scrapped.

Inspection is low cost with Magnaflux' Methods and it finds all cracks...helps you find the cure. It can save you many times its trifling cost.

Ask to have a Magnaflux engineer give you facts and figures—or write for new booklet on LOWER MANUFACTURING COST.

MAGNAFLUX

MAGNAFLUX CORPORATION
7348 West Lawrence Avenue • Chicago 31, Illinois
New York 36 • Pittsburgh 36 • Cleveland 15
Detroit 11 • Dallas 19 Los Angeles 58

THROUGH THE SCHOOL OF HARD KNOCKS WITH FLYING COLORS!

The Fairchild C-123 was especially designed for landings and take-offs on rough, unprepared fields.

FAIRCHILD C-123 PASSES OPERATIONAL SUITABILITY TESTS

Now being subjected to rugged tests for the U. S. Air Force, the Fairchild C-123 Assault Transport has proved it can withstand the rigors of any combat airlift mission and win an "A" for top performance!

Shown above is an actual photograph of a C-123 making a short field landing downwind over a 50-foot obstacle on a sandy, deeply rutted strip at Eglin Air Force Base. During other tests the C-123 was flown in simulated front line combat airlift missions and proved its durability by landing and taking off on extra rough terrain in the shortest possible distance.

The Fairchild C-123 is literally built to "take it tough" on any assigned Air Force mission . . . another example of the rugged, hard-job dependability built into Fairchild utility and logistics aircraft.

Litter patients, airborne troops or almost 10 tons of bulk equipment may be airlifted by the C-123. A built-in ramp facilitates *quick loading and unloading of cargo and troops.*

During "Operation Shakedown", the C-123 was subjected to 500 hours of rugged duty under all operational conditions.

A Division of
Fairchild Engine and Airplane Corporation.

FAIRCHILD

AIRCRAFT DIVISION • HAGERSTOWN, MARYLAND

. . . WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!

How Aluminum parts

For better parts at lower cost . . .

help Ford cut costs

THE Ford Motor Company recently changed its specifications on the Ford car windshield wiper knob insert to aluminum. This Ford part is one of several new screw machine parts now made from aluminum. They are currently studying other screw machine parts for possible conversion to aluminum.

This conversion met the requirements of management, design engineering and production groups.

Management requirement: Savings

Change to aluminum saved approximately 24.8%. Ford management is always interested in materials or methods that will effect savings with no sacrifice in quality. In this particular case, as in others, aluminum was selected because it provided savings of about 24.8% per piece, including scrap loss. Also, the aluminum parts are so much lighter than the previously used metal, that Ford has realized additional savings in shipping costs.

Designer requirement: Performance

Aluminum met design specifications. Ford engineers selected aluminum alloy 2011-T3, ⅜" round stock after they tested other metals and found that the aluminum knob insert would not only provide sufficient strength but would also take a slightly better knurl. The fact that aluminum satisfied performance requirements and for less money than other metals tested, was the main consideration in Ford's selection of aluminum.

Operator requirement: Machinability

Aluminum machined at maximum efficient cutting speed. The changeover to aluminum for this knob insert did not require any change in machining speed and setting from the previous metal used. Ford is running the part successfully at the maximum efficient speed of the automatic screw machine. And Ford found that it was not even necessary to change the angle of the form tool, which is an ordinary high speed steel tool with no chip-breaker.

The experience and engineering know-how of Ford has proved that properly designed aluminum parts can often provide substantial economies plus high quality.

You get these big advantages with aluminum

Each part costs less because you get *three times* as many parts from a pound of Kaiser Aluminum screw machine stock as you get from a pound of brass or steel. And these parts give you a unique combination of advantages, including lightness with strength, handsome finish, corrosion resistance, good heat and electrical conductivity.

Because of economy, plus these other advantages, we predict that hundreds of aluminum screw machine parts will soon become standard in American motor cars; for example, heater fan hubs, master brake cylinder pistons, door lock buttons, tire valves and spark plug terminals, compression fittings for gas and oil lines, hood release cable stops.

Our engineers will be glad to examine the screw machine parts now being used in your production to see how you can effect substantial savings by specifying them in Kaiser Aluminum.

Also, if you need assistance in finishing, welding, forging, roll-forming, extrusions, stampings, castings—or desire any type of engineering service and fabricating counsel—our development engineers will gladly provide it.

We may be able to suggest modifications in your designs, new fabrication techniques, changes in aluminum alloys—all of which may give you a better product at lower cost.

For immediate service, contact Kaiser Aluminum & Chemical Sales, Inc. *General Sales Office,* Palmolive Building, Chicago 11, Illinois. *Executive Office,* Kaiser Building, Oakland 12, California.

think of Kaiser Aluminum

ENGINEERS

you advance professionally, as you develop advanced jet and rocket engines

...at GENERAL ELECTRIC'S AIRCRAFT GAS TURBINE DIV.

GE engineers are given full scope to formulate their ideas... full freedom to "sell" them to the small, congenial team of experts with whom each man works... full facilities to carry through a conception of the model, test and evaluation stages.

This environment at GE—so beneficial to scientific work—draws the best from a talented man. No wonder the individual engineer grows steadily in professional stature, as "his" project progresses.

Here are genuine opportunities for engineers eager to do original work with a leading company, in a field of ever-growing importance—the development of advanced propulsion systems.

The plant is located in the outskirts of Cincinnati, close to many pleasant suburbs. The city provides notable education facilities, where GE engineers often do graduate study on a full tuition refund plan.

POSITIONS NOW OPEN AT ALL LEVELS
(Do not involve board work)

Preliminary Design
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GENERAL ELECTRIC

CINCINNATI 15, OHIO

You Get INSTANT Protection...
You Get AUTOMATIC Protection...
Plus Shorter Stopping Distance...
WITH MIDLAND Break-Away
SAFETY CONTROLS!

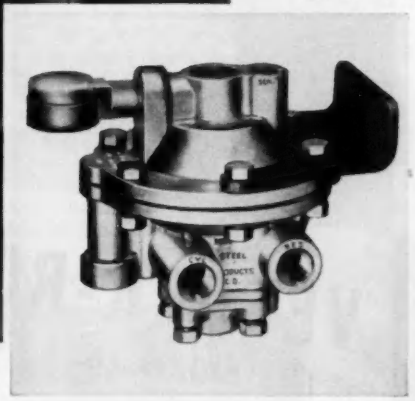
It's Good Business—And Good Public Relations, Too—to Equip Your Tractor-Trailer Units With MIDLAND Safety Controls—And Your Drivers Will Be The First To Thank You!

If you operate tractor-trailers equipped with air brakes, break-away safety controls are of course required by the ICC on all tractors built since June 30, 1953, but for maximum protection specify *Midland* Break-Away Safety Controls.

Midland's break-away valve is *fully-automatic!* Another major benefit—you get shorter service stops when you use Midland's break-away valve.

Midland's break-away safety system involves its *fully-automatic* Break-Away Valve, with Check Valve. It is supplemented by an audible signal which notifies the driver of low air pressure. This is accomplished by the use of an *automatic* Low Pressure Switch, and a dependable warning Buzzer—all thoroughly proved in service.

Because Midland's break-away safety system is *fully-automatic,* the driver has only to apply service brakes in the usual manner. *There are no additional controls to operate*—and brake function is fully restored after the vehicles have been re-connected.



On Midland-equipped units, if trailer should break away from tractor, warning Buzzer sounds . . . instant-acting Reservoir Check Valve *automatically* seals air supply, providing tractor with sufficient reserve . . . Break-Away Valve (illustrated) permits tractor brakes to be applied to bring tractor to safe stop . . . trailer braking system *automatically* applies emergency feature to stop trailer!

Midland break-away safety controls are available in complete kits and are easily installed. For information and prices, see your local Midland Distributor.

THE MIDLAND STEEL PRODUCTS CO.
3641 E. Milwaukee Avenue • Detroit 11, Michigan
Export Department: 38 Pearl Street, New York, N.Y.

Those Who Know Power Brakes Choose
MIDLAND!

"How do you know when an engine needs attention?"

...you get the Complete Answer from the built-in

VEEDER-ROOT Rev-Counter

These rugged counters record the shaft-revolutions of engines, generators, compressors, heaters and other equipment. So you *and your customers* can see at a glance how your equipment is holding up to its guarantee . . . whether it needs replacement parts . . . when routine maintenance is coming due.

That's why it pays, in designing engines of any type, to build-in the genuine Veeder-Root Rev-Counter as a standard integral part . . . as has been done for many years by leading builders of tractors and aircraft.

Take note, too, that this counter is available with *tachometer take-off* . . . and that it may be furnished geared to any engine rpm. So build up your sales . . . build the Veeder-Root *Rev-Counter* into *your* product. Write:

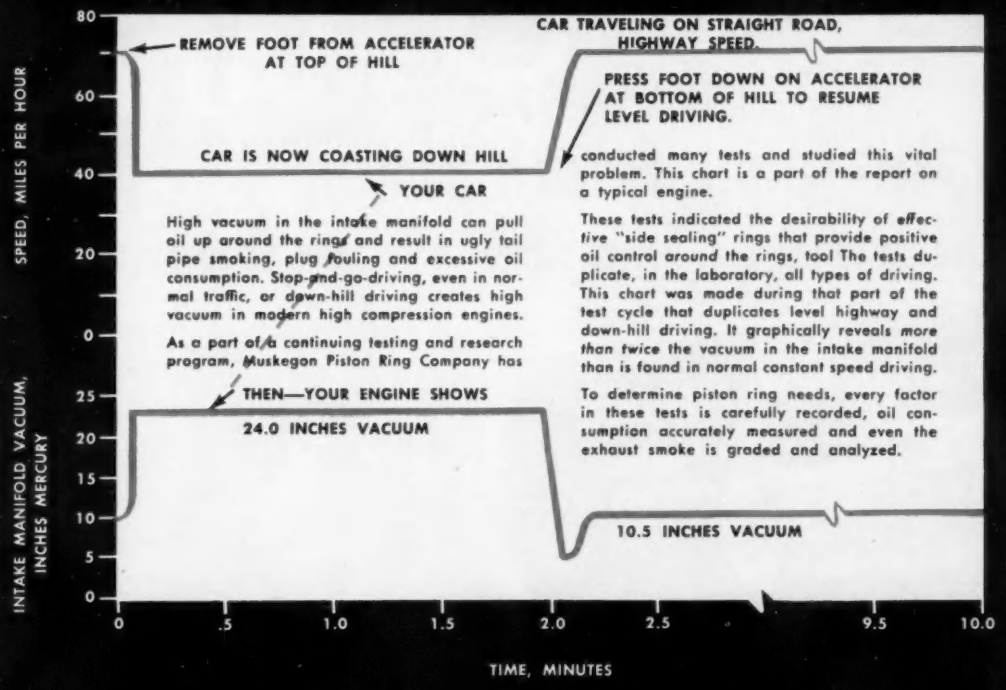
Everyone can Count on...

VEEDER-ROOT
The Name that Counts

VEEDER-ROOT INCORPORATED
HARTFORD 2, CONNECTICUT

STOCKS OF STANDARD COUNTERS AVAILABLE AT
Greenville, S. C. • Chicago 6, Ill. • New York 19, N. Y. • Los Angeles • San Francisco
Montreal 2, Canada • Offices and Agents in Other Principal Cities

High Vacuum Creates Oil Control Problems...



High vacuum in the intake manifold can pull oil up around the rings and result in ugly tail pipe smoking, plug fouling and excessive oil consumption. Stop-and-go-driving, even in normal traffic, or down-hill driving creates high vacuum in modern high compression engines.

As a part of a continuing testing and research program, Muskegon Piston Ring Company has conducted many tests and studied this vital problem. This chart is a part of the report on a typical engine.

These tests indicated the desirability of *effective* "side sealing" rings that provide positive oil control *around* the rings, too! The tests duplicate, in the laboratory, all types of driving. This chart was made during that part of the test cycle that duplicates level highway and down-hill driving. It graphically reveals *more than twice* the vacuum in the intake manifold than is found in normal constant speed driving.

To determine piston ring needs, every factor in these tests is carefully recorded, oil consumption accurately measured and even the exhaust smoke is graded and analyzed.

Muskegon's New "Side-Sealing" Piston Rings Solve 'Em!

Using these extensive laboratory tests as an engineering basis, Muskegon has designed three new "Unitized" oil control rings that cover the problems created by high intake manifold vacuum.

These new "side sealing" rings incorporate a wedge action that effectively seals the ring grooves to prevent oil flow around the rings. They also incorporate the features that have made Muskegon rings synonomous with performance and long life. They're chrome plated and lapped to give faster break-in and reduced wear. They're "Unitized" to provide faster handling and error-proof installation. A special adhesive is used to bind the ring components together... the adhesive dissolves during run-in, leaving the pieces free to form a perfect seal.

These new "side sealing" piston rings are available now. Write today for complete details. Give us your ring requirements and specifications and we will furnish quotations and samples for your examination. *Muskegon Piston Ring Co., Muskegon, Michigan.*

Patent Number 2,140,710

MUSKEGON Piston Rings

Since 1921... The engine builders' source!

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MUSKEGON, MICHIGAN
PLANTS AT MUSKEGON AND SPARTA

DETROIT OFFICE: 521 New Center Bldg.
Telephone: Trinity 2-2113

CLEAR-O-MATIC*

The All-Temperature Piston

UNIFORM SKIRT CLEARANCE FROM 20° BELOW ZERO TO 200° F

STEEL TENSION MEMBER

Anchored only at pin bosses and cast in positive contact with I.D. of piston skirt

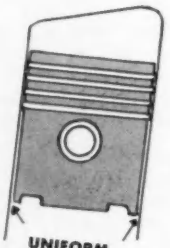
Controls Clearance Automatically

DESIGN ADAPTABLE TO FULL SKIRTED OR SLIPPER TYPE PISTONS FOR GASOLINE ENGINES FOR EVERY PURPOSE

Sensational Performance

Requires less than .001 Clearance

Cold or Hot, Clear-O-Matic Piston clearance stays constantly uniform. Required clearance is reduced to less than .001. This great development of the "All-Temperature" Piston by Zollner engineers provides another fine feature attraction for the modern motor car . . . smooth, quiet running engine . . . no cold slap . . . reduced friction without loss of durability or heat conductivity . . . no danger of scuffing or seizing. We suggest a test of these sensational performance advantages for your engine.



UNIFORM EFFECTIVE SKIRT CLEARANCE AT ALL TEMPERATURES

1. Clearance maintained uniformly at all coolant temperatures from 20° below zero to 200° F.
2. Effective expansion identical with ferrous cylinder.
3. Steel tension member, with same effective expansion as cylinder, maintains uniform skirt clearance through entire temperature range.
4. Normal diametric clearance usually less than .001 with uniform skirt bearing.
5. Durability and conductivity comparable to heavy duty design.

*T.M. Reg. Pat. App. For

ADVANCED ENGINEERING

PRECISION PRODUCTION

COOPERATION with Engine Builders

ZOLLNER PISTONS

THE ORIGINAL EQUIPMENT PISTONS

ZOLLNER

ZOLLNER • Fort Wayne, Indiana

A message to the Career-Conscious Engineer:

Ready to change jobs?

Perhaps you are not receiving a salary commensurate with your work.

Perhaps you are dissatisfied with your rate of promotion.

Perhaps you do not have enough scope for your abiilty in your present job.

Or perhaps you simply want to move to Southern California.

We invite you to consider the California Division of Lockheed Aircraft Corporation as the place to re-establish your career. For these reasons:

Promotional Opportunities are excellent because there are so many supervisory positions to be filled with 46 major projects in progress at Lockheed and because Lockheed is in an expanding development and production program.

You have more scope to show what you can do because Lockheed projects range across virtually the entire spectrum of aeronautical endeavor. You are not limited to one type of work because Lockheed is so diversified in projects. Moreover, Lockheed encourages and welcomes personal initiative.

You may receive a substantial increase in pay because Lockheed is extremely liberal in direct salary and in extra employee benefits, which actually increase the value of your position by an average of 14%.

You will enjoy life in the San Fernando Valley where a healthful, sunny climate combines with scenic beauty to offer you a daily "bonus" in good living after hours.

Positions are open at all levels for engineers in fields of: Aerodynamics – Design – Electronics, with emphasis on systems and antenna design – Flight Test Engineering, particularly in instrumentation – Math. Analysis – Operations Research – Structures – Thermodynamics.

Space prevents us from listing all the reasons we believe you will find significant. There are many others. But if our brief remarks make sense to you, write us and we can explore your opportunities at Lockheed through personal interview or phone. The brief resumé below is simply for your convenience in contacting us.

TO ENGINEERS WHO LACK AIRCRAFT EXPERIENCE:

Aircraft experience is not necessary to join Lockheed. It's your engineering training and experience that count. Lockheed trains you for aircraft engineering – at full pay.

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Lockheed Aircraft Corporation
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On highways and skyways . . .

To the leading builders of automobiles and aircraft, Kelsey-Hayes is a major source of vital parts. The large resources of Kelsey-Hayes make possible wide diversification, such as automobile wheels, brakes and brake drums, to name but a few. Equally important, in the aviation field, Kelsey-Hayes supplies engine components, assemblies and many other vital products.

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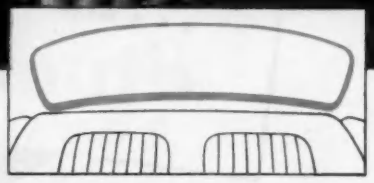
Kelsey-Hayes Wheel Co., Detroit 32, Mich. • Major Supplier to the Automotive, Aviation and Agricultural Industries

TEN PLANTS / Detroit and Jackson, Michigan; McKeesport, Pa.; Los Angeles, Calif.; Windsor, Ontario, Canada • Davenport, Iowa (French & Hecht Farm Implement and Wheel Division) • Springfield, Ohio (SPECO Aviation, Electronics and Machine Tool Division)



Dodge selects Enjay Butyl rubber for big rear-window weatherstrip

Super-durable Enjay Butyl fits perfectly Dodge's rigid specifications for its rear-window weatherstrip. Under the toughest conditions of weather and use, Enjay Butyl parts stay like new, help add style and color to new cars. In fact, some automobiles have more than 100 parts made of this fabulous rubber.

The many advantages of Enjay Butyl make it the almost perfect rubber for the automotive industry. Its price and ready availability are advantages, too. And it is now available in non-staining grades for *white* and *light-colored* parts. For full information and for skilled technical assistance in the uses of Enjay Butyl, contact the Enjay Company at either of the addresses below.

ENJAY

BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY **ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.**
District Office: 11 South Portage Path, Akron 3, Ohio.

36 SUCCESSFUL YEARS OF LEADERSHIP IN SERVING INDUSTRY

CURTISS-WRIGHT METALS PROCESSING DIVISION CAN COMBINE QUALITY WITH ECONOMY IN YOUR PRODUCTION TOO!

This nickel alloy casting by the Curtiss-Wright Metals Processing Division costs 40% less than identical previous castings. The saving, however, is almost a sidelight to the fact that specialized know-how can discover routes to quality that are often far shorter as well as less expensive.

High Standards, Lower Cost

In this case the answer to meeting high standards and lower cost was ceramic mold instead of investment casting. This method in experienced hands retained the close tolerances required . . . produced castings faster, and with gratifying economy.

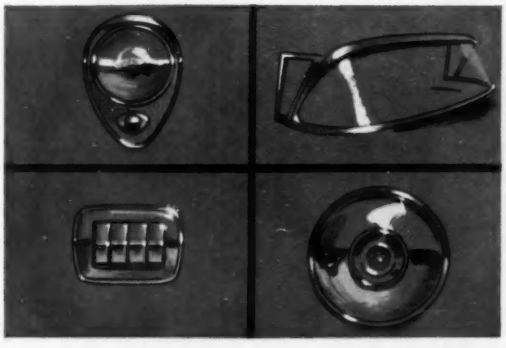
Metals Processing Division metallurgical specialists can find answers for you, whether in ceramic, shell, centrifugal or other techniques . . . standard or special. You will profit by long-proven engineering ability and unmatched facilities in production and testing. When requirements are critical, when precision must be combined with resistance to heat, stress, wear and corrosion, it's time to call on Curtiss-Wright—a primary source for castings, forgings and extrusions.

METALS PROCESSING DIVISION
CURTISS-WRIGHT
CORPORATION • BUFFALO, NEW YORK

77 Grider Street, Buffalo, New York

modern design specifies stainless steel

McLouth
STAINLESS
Steel
for automobiles

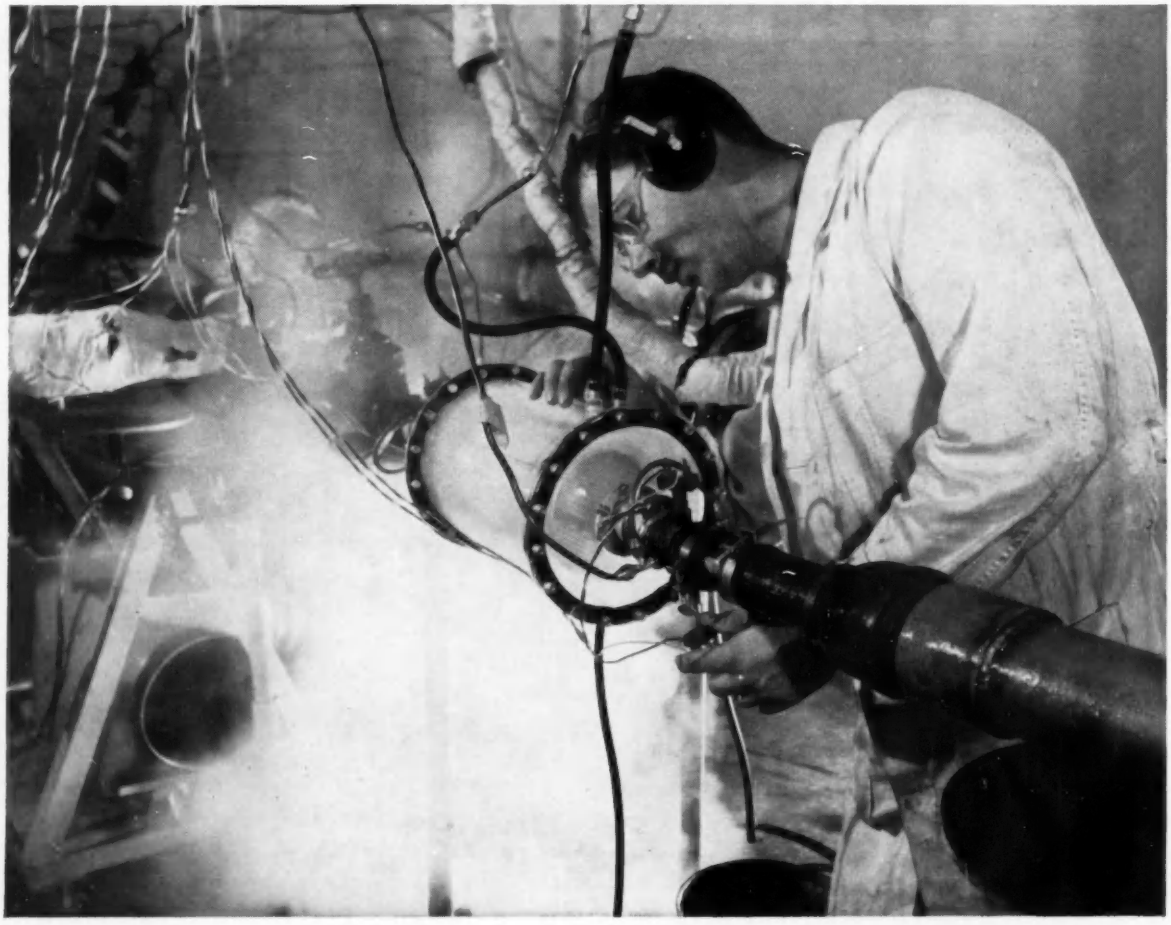


The beautiful bright molding and trim that style your car are made of non-corrosive, easy to clean Stainless Steel. Designers of automobiles and hundreds of other products specify Stainless Steel for its many valuable properties.

For the product you make today and the product you plan for tomorrow specify McLouth high quality sheet and strip Stainless Steel.

McLouth Steel Corporation
Detroit, Michigan

MANUFACTURERS OF STAINLESS AND CARBON STEELS



How to wring water out of thin air...

Lab test proves water-separator's effectiveness in air conditioning system

In air conditioning an airplane cabin, compressed air is cooled by heat exchangers, then further cooled by a turbine. However, at low temperatures the vapor in the air condenses into water droplets. If uncontrolled, these would enter the cabin as fog; but the excess water is removed by a water-separator.

The system is simple in principle but efficient in operation only when each component is a top performer, proved by exhaustive testing under flight conditions. And that is exactly what happens at AiResearch, where production is guided by the finest and most comprehensive test facilities of their kind in America.

You can depend on the systems and components manufactured by AiResearch.

Qualified engineers in the fields listed below are needed now. Write for information.

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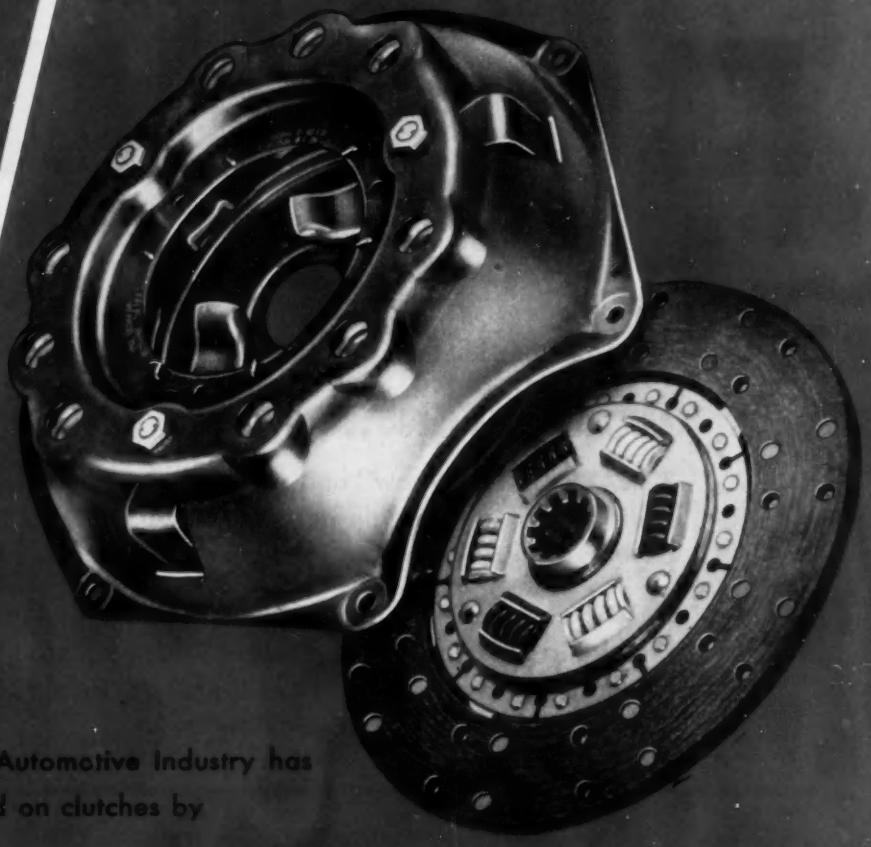
Designers and manufacturers of aircraft systems and components: REFRIGERATION SYSTEMS · PNEUMATIC VALVES AND CONTROLS · TEMPERATURE CONTROLS CABIN AIR COMPRESSORS · TURBINE MOTORS · GAS TURBINE ENGINES · CABIN PRESSURE CONTROLS · HEAT TRANSFER EQUIPMENT · ELECTRO-MECHANICAL EQUIPMENT · ELECTRONIC COMPUTERS AND CONTROLS

QUIETER OPERATION

SMOOTHER PERFORMANCE

BETTER SERVICE

LONGER LIFE



For more than 35 years the Automotive Industry has found you can always depend on clutches by

BORG & BECK®

For that vital spot where Power takes hold of the load!

BORG & BECK CLUTCH · THE STANDARD ·

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The Standard Clutch—A Product of Borg-Warner

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ENGINEERING B-W PRODUCTION

Borg-Warner Corporation
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7 Year Success Story

YOU'RE YEARS AHEAD WITH

DUALOY*

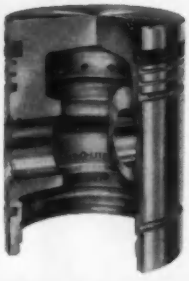
ARMORED RING BAND INSERT PISTONS

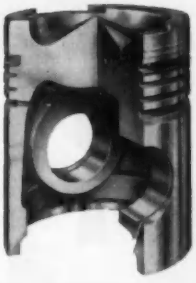
Read this Record of Proven Performance

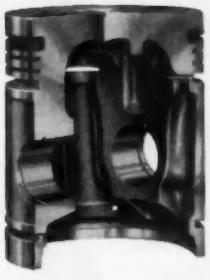
MORE THAN...

7 YEARS of "know-how" and successful production. 1,000,000 DUALOY pistons installed in operating equipment. 2,000,000,000 MILES of heavy-duty highway transport operation—without a failure of the chemically bonded top ring groove insert.

In 1948 the manufacturers of DUALOY designed and developed the 1st successful bimetallic molecular bonded piston. Today it is still the No. 1 heavy duty piston with a full line of heavy duty pistons for all standard engines, bores and oversizes, and to fit all standard sleeve assemblies.







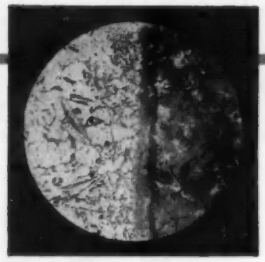
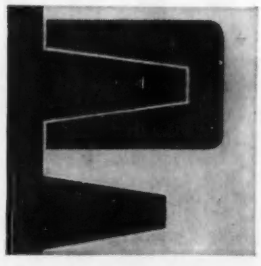


Photo micrograph of DUALOY* bi-metallic molecular bond.



Enlarged cutaway of DUALOY* ni-resist ring groove.

DUALOY **the first name in heavy duty pistons**
the last word in proven performance.

***Manufactured by* UNITED ENGINE & MACHINE COMPANY**

310 Preda Street, San Leandro, Calif.

Better Pistons Since 1922

SPECIFY DUALOY PISTONS

DUALOY*
MAKES THE GRADE

1949 DUALOY INSTALLS FIRST PRODUCTION PISTONS IN 2 HIGHWAY TRANSPORT TRUCKS AND 1 HIGHWAY BUS.

1950 First Engine Manufacturer specifies DUALOY as original equipment in Diesel heavy-duty engine.

1951 43 conventional Silv-o-lite pistons now converted to DUALOY numbers. 1st experimental set reaches 200,000 mile mark!

1952 11 fleet owners,—692 transport operators now using DUALOY pistons exclusively in heavy duty rigs.

1953 Bus operator reports on DUALOY pistons installed in 1950. "250,000 miles—no appreciable wear, pistons re-ringed and re-installed."

1954 Operational records now reach 500,000 miles. Fleet-owner reports "Fleet average in excess of 250,000 miles."

1955 153 conventional Silv-o-lite pistons now converted to DUALOY numbers—over 1,000,000 DUALOY pistons sold and installed . . . . .

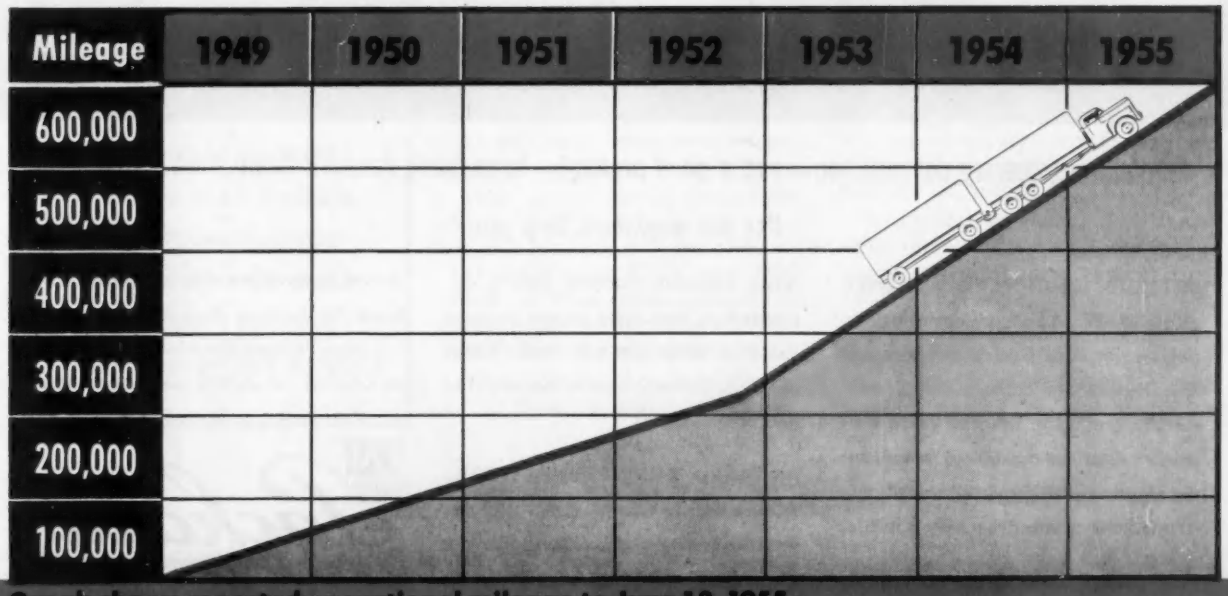
NO FAILURE TO DATE DUE TO EXCESSIVE WEAR IN AREA OF CHEMICALLY BONDED ARMORED RING BAND INSERT.

Better Pistons Since 1922

Manufactured by

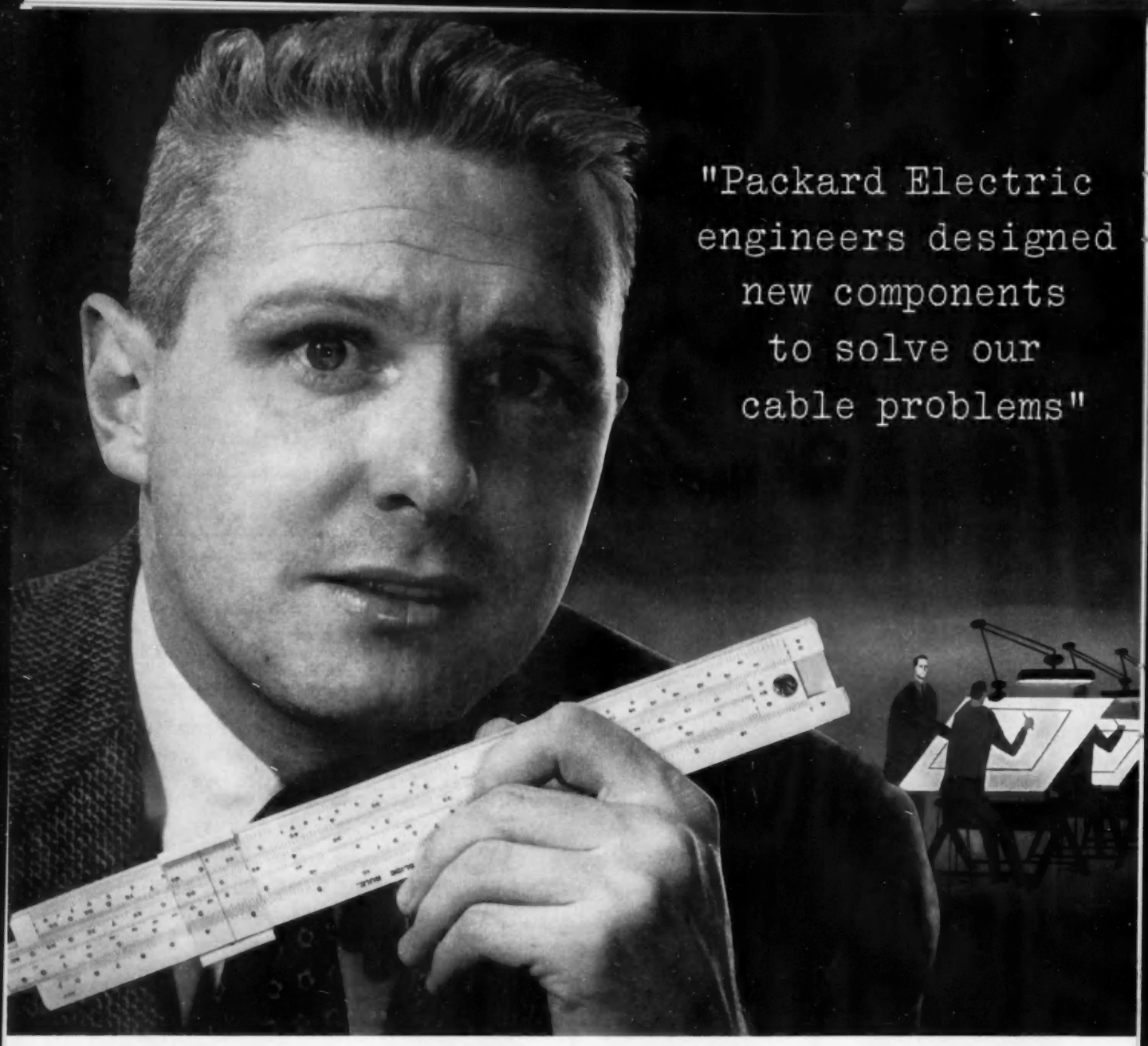
UNITED ENGINE & MACHINE COMPANY

310 Preda Street, San Leandro, Calif.



Graph shows reported operational mileage to June 18, 1955

AVAILABLE FOR YOUR ENGINES



Sound engineering consultation—and a good product—have made Packard Cable first in sales.

Can our engineers help you?

TO LESSEN IGNITION INTERFERENCE on radio, TV and other communication devices, Packard Electric developed a new, high-tension cable built with non-metallic conductor. This new cable suppresses electrical oscillations throughout the length of the circuit instead of only at one point as was previously possible.

FOR CABLE SUBJECTED TO ABRASION, weathering and other deteriorating elements, Packard Electric developed a new type plastic exterior insulation which not only *works* better but *looks* better on truck, tractor, boat and other engines.

PACKARD ENGINEERING WORKS FOR YOU in many ways. Whether you need a new cable component or a complex wiring harness, ready for snap-in installation—it will pay you to discuss the problem with us. Because we know the business *from the inside out* . . . more Packard Electric cable is used as original automotive equipment than all other makes combined.

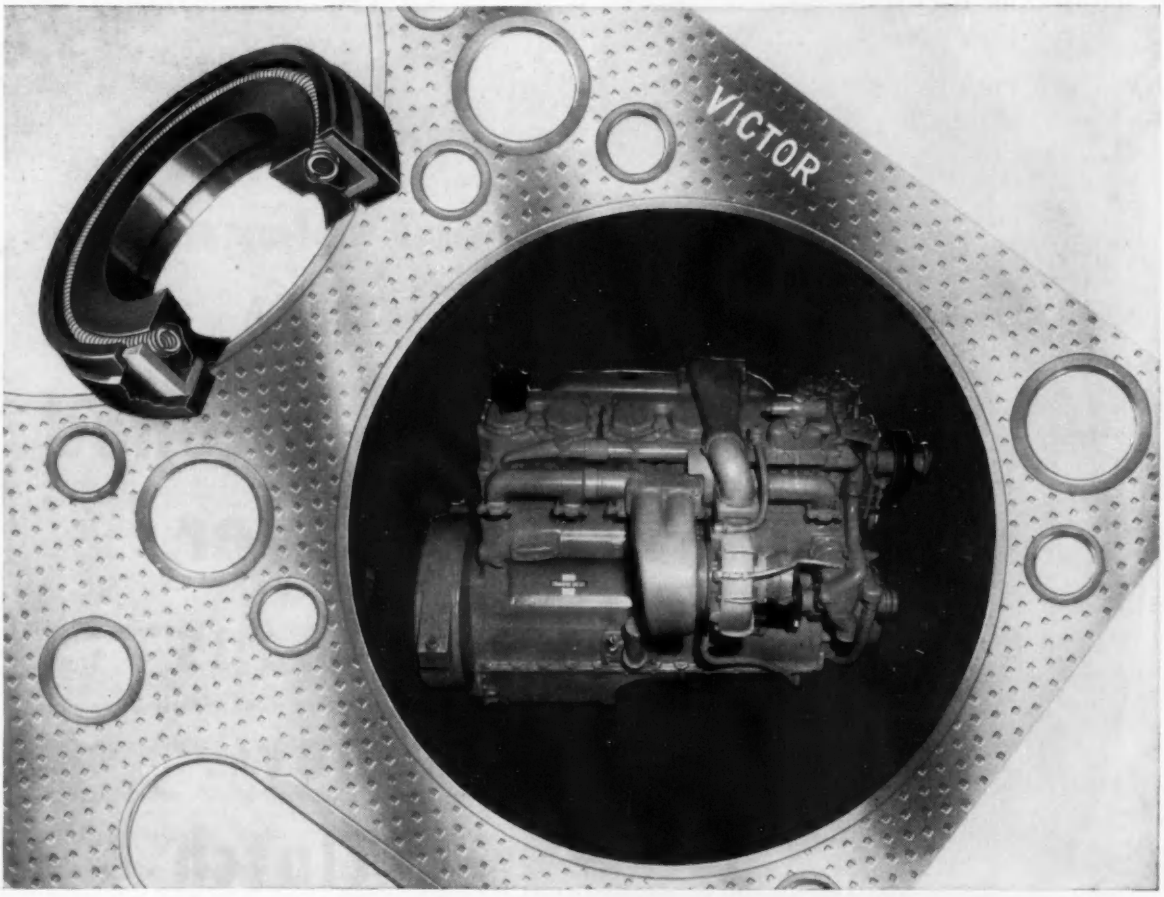
GM GENERAL MOTORS

Packard

REG. U.S. PAT. OFF.

Packard Electric Division
General Motors, Warren, Ohio

Offices in Detroit, Chicago, and Oakland, California • Aviation, Automotive and Appliance Wiring



Long life of CUMMINS *TURBODIESELS* assured with VICTOR sealing

Quality Sealing Products for Every Vital Point

- **VICTOPAC PACKING**
- **VICTOR HEAD GASKETS**
- **VICTOLEX PACKING**
- **VICTOPRENE OIL SEALS**
- **VICTORITE PACKING**
- **VICTOR MANIFOLD GASKETS**

By matching power to job requirements, Cummins Turbodiesels deliver long-life, low-cost performance. And Cummins' designers see to it that maximum horsepower output is maintained.

With quality sealing components they prevent fuel waste and compression loss, and leakage of lubricant and coolant. They know that quality in these parts—gaskets, oil seals and packings—makes a powerful difference in engine performance.

Victor sealing is quality sealing for all types of heavy-duty power units. Victor's continuing research and development of materials and structures assure the ultimate design for each sealing need. Each Victor packing, for example, is classified and defined for service by SAE-ASTM specification.

In addition to sealing skill since 1909, Victor offers unmatched facilities for quality mass production. Let's get our engineers together.

Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. In Canada: Victor Mfg. & Gasket Co. of Canada Limited, St. Thomas, Ont.

VICTOR

Sealing Products *EXCLUSIVELY*

GASKETS • OIL SEALS • PACKINGS

air-conditioned cover keeps new clutch c-o-o-l

Frictional heat has little effect on the new *Lipe* Direct Pressure Clutch. Air circulating through the cover's 33 ventilating holes dissipates heat rapidly. The result is a heavy-duty clutch singularly free of burned facings and warped pressure plates. A clutch whose low maintenance cost matches its low first cost.

Lipe Direct Pressure Clutches now available: 13", 14", 15" single-plate, 14" and 15" two-plate. Send for complete information.

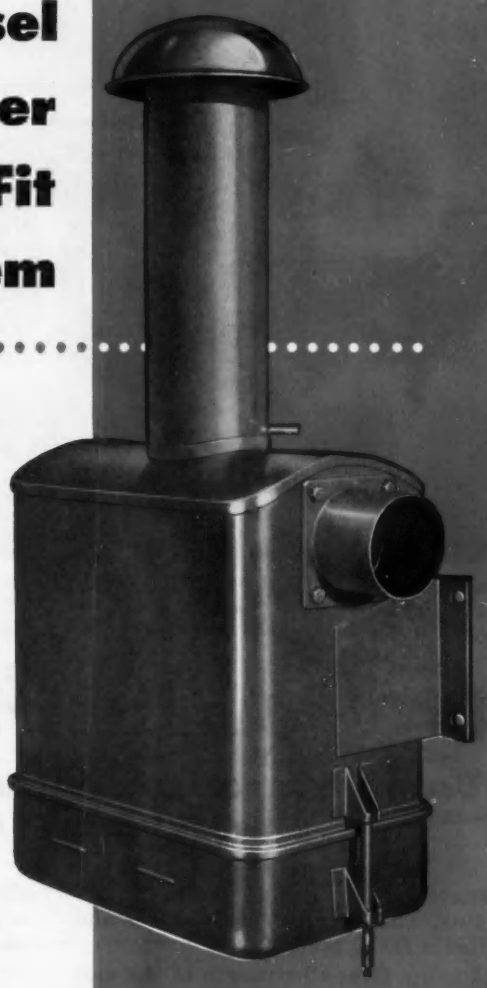
For the name of your nearest Authorized Lipe Distributor, look under "Clutches" in your telephone directory. Or, write us.

Manufacturers of Automotive Clutches & Machine Tools

LIPE ROLLWAY

Lipe-ROLLWAY CORPORATION SYRACUSE 1, N. Y.

Rectangular Diesel Air Cleaner Solves Tight Fit Problem



Problem: United Specialties was confronted with the problem of designing a diesel oil bath air cleaner which could be fitted into limited under-the-hood space.

Solution: United engineers departed from the conventional round shape and designed a new rectangular air cleaner which was shaped to fit into the available space, providing more room for accessories. This new cleaner with instantly removable dual filters is available in the following sizes:

5¾ x 9½ for an air capacity of 175 cfm
6½ x 11 for an air capacity of 240 cfm
7½ x 12¼ for an air capacity of 300 cfm
8¾ x 14 for an air capacity of 400 cfm
10 x 16 for an air capacity of 525 cfm
11½ x 19½ for an air capacity of 740 cfm

Here is another example of how United Specialties engineers helped solve a tough design problem. We invite your inquiry.

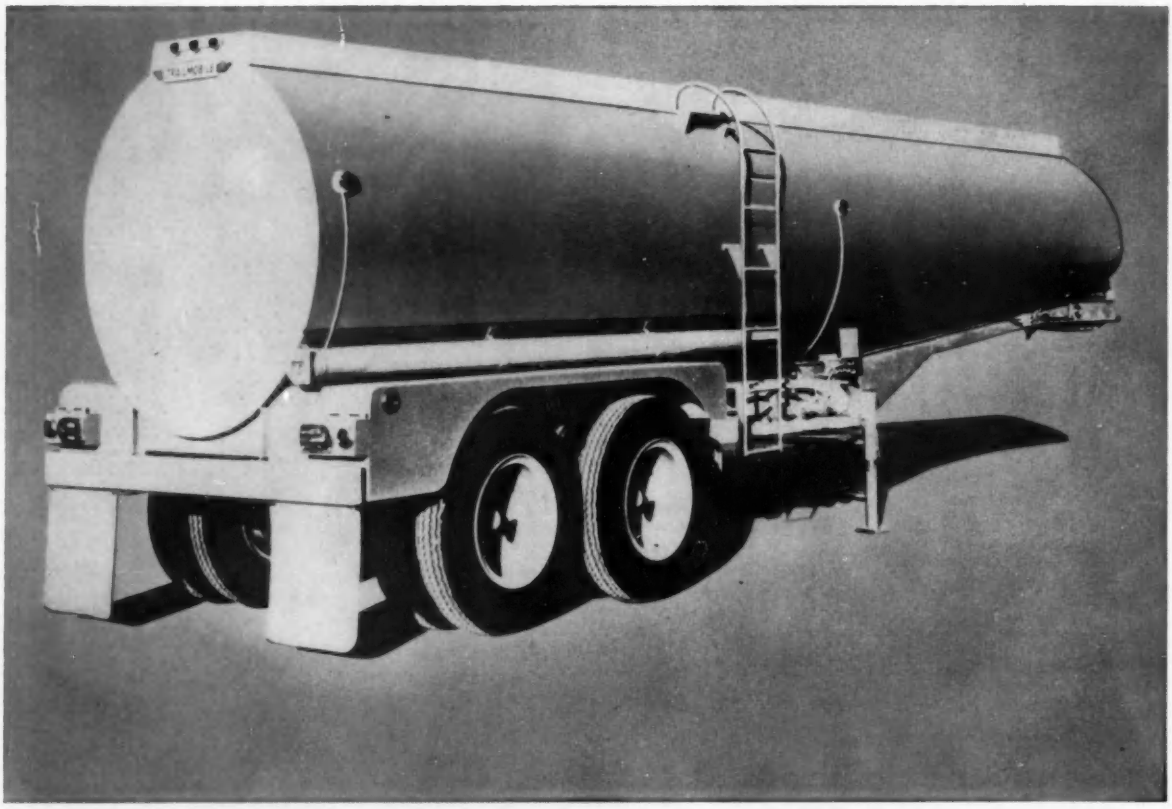
United Specialties Company

Air Cleaners • Metal Stampings
Rolled Shapes • Ignition Switches
Turn Signal Switches • Dovetails

United Air Cleaner Division
Chicago 28, Illinois

Mitchell Division
Philadelphia 36, Pa.

Birmingham 11, Alabama



Most recent design of lightweight steel tank-trailer developed by the Tank Division, Trailmobile, Inc., at Springfield, Mo., where the unit is now in production. Designers stripped off needless weight by using USS COR TEN, a high-strength, low-alloy steel containing nickel, produced by United States Steel Corp., Pittsburgh, Pa.

2440 pounds trimmed off...

Use of high strength low alloy nickel-copper steel adds capacity to trailer

REDUCED OPERATING COST is one result of this weight reduction. There's less wear on tires and brakes. And fuel is saved every day.

Yet payload is up. Over-all strength of the unit is unchanged.

In place of hauling needless weight every trip, this tank-trailer can deliver 400 extra gallons of gasoline or 340 extra gallons of fuel oil. Either increases revenue per ton mile.

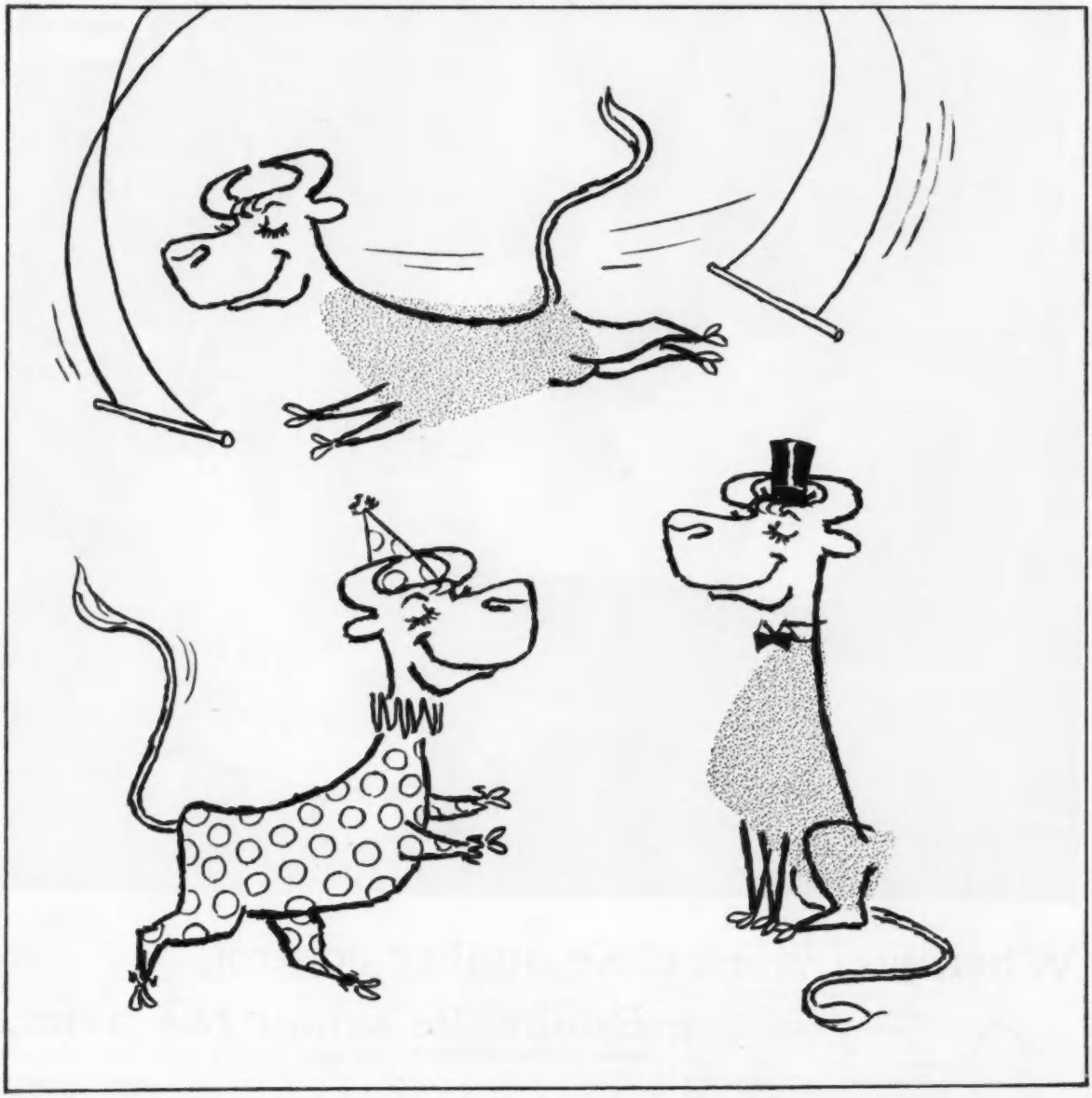
Engineers at Trailmobile, Inc. aimed for several advantages by using basic properties of high strength low alloy steel containing nickel. In thin light section, steels of this type provide the same strength as thicker, heavier sections of carbon steel. But reduction of deadweight is not the entire story.

Offering high resistance to atmospheric corrosion . . . 4 to 6 times that of carbon steel . . . the nickel alloyed steels retain a high proportion of their original strength during years of use. This assures longer equipment life and cuts down maintenance and repair costs.

In addition, you'll find that high strength low alloy steels containing nickel can be hot or cold formed about as readily as mild carbon steels. Use of these steels helps to reduce unit labor cost as well as production time.

Produced under various trade-names by leading steel companies, high strength low alloy steels containing nickel along with other alloying elements, offer money-saving advantages. Learn more about these steels . . . send for a copy of "Nickel-Copper High Strength Low Alloy Steels." It discusses design factors, corrosion-resistance and the like. Write for it now.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.

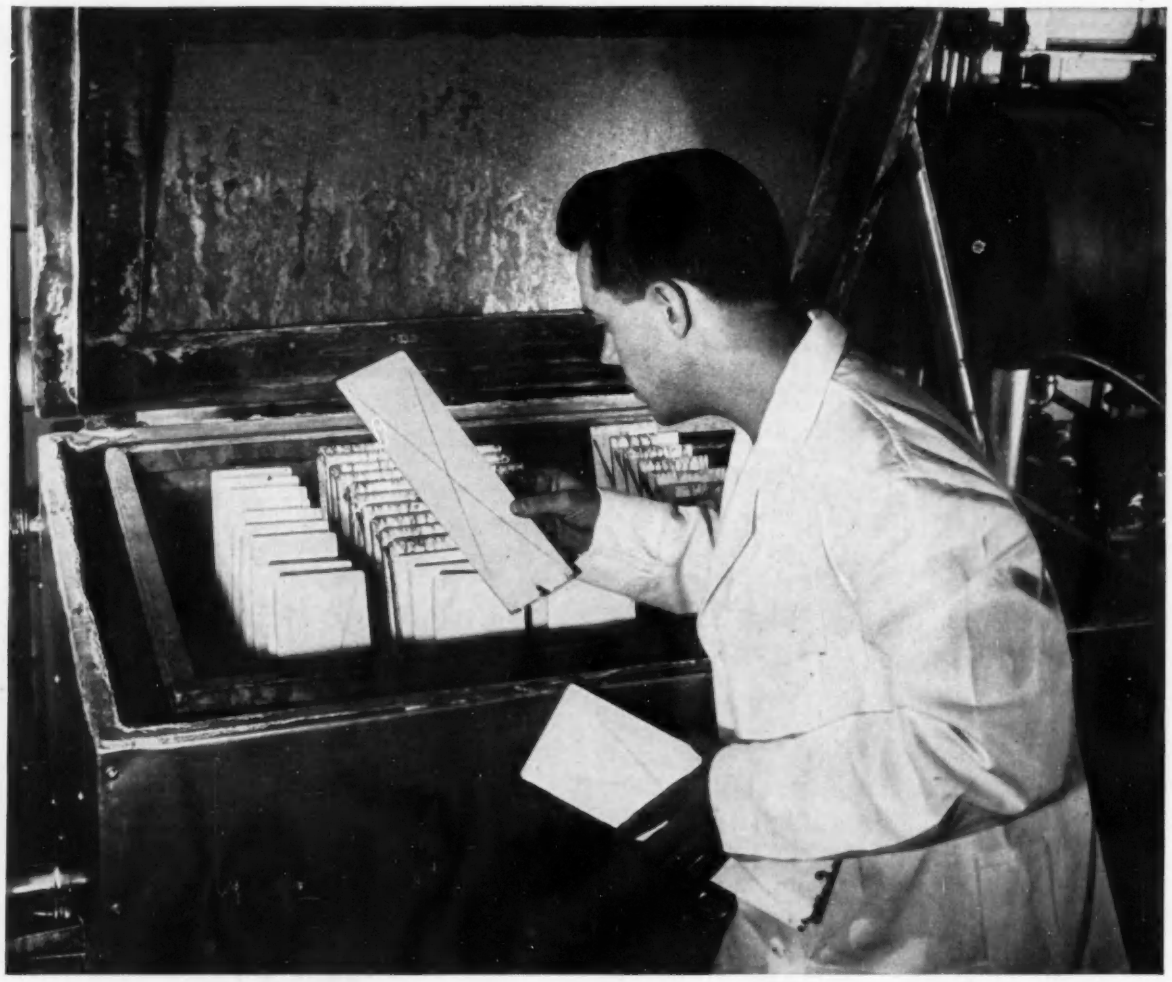


For versatility... genuine Leather

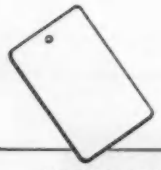
You can recommend genuine leather upholstery with confidence, no matter what model you are selling. It's practical enough for the family car, brilliant enough for a sports car. It has the prestige and dignity needed for a limousine, and the high-fashion that's right in a hardtop. Your customers get more value, and you make more sales, when you sell genuine leather upholstery.

Only genuine leather wears as well as it looks

THE UPHOLSTERY LEATHER GROUP, INC. • **99 West Bethune, Detroit 2, Mich.** • 141 E. 44th St., New York 17, N. Y.



When you want close quality control, *you use Bonderite under the paint.*



"GOLD STANDARD" PANELS are Bonderized

Parker's Customer Service lab prepares Bonderite-treated panels, used as the standard of comparison by manufacturers and paint companies. We have shipped about 400,000 in the last 12 months.

● The test panels in the plant laboratory tell the story: Bonderite in the finish line is the quality control engineer's friend. Performance standards are more easily maintained. And when standards are maintained in the plant, product performance in the field will please your customers.

The secret of Bonderite's uniform results begins in Parker manufacturing plants, where each lot of chemical is numbered and tested. A sample is kept permanently. Operating procedures for processing are simple, easily followed, easily checked. Long experience has smoothed out all the kinks!

Take the most positive way to control quality and assure finest paint finish, durability and appearance—use Bonderite.

**Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U.S. Pat. Off.*

PARKER RUST PROOF COMPANY
2181 E. MILWAUKEE, DETROIT 11, MICHIGAN

Since 1915—leader in the field

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

Another Famous AC Automotive First

Remember how instrument needles "fluttered" with vehicle movement and at every road irregularity? People got used to it, but they *never* liked *guessing* what the gauge was actually trying to record.

Then, in 1945, AC came up with the solution that brought needle-steadiness to instruments. They found the answer in the flat viscosity curve of silicone fluids. A drop of silicone on the needle mounting provided a friction component or damper to hold the pointer steady. Wiggle and flutter were licked by this ingenious application of silicone stability characteristics.

AC engineers have developed many solutions for automotive problems and racked up many impressive firsts like this in the industry. AC counsel and AC facilities are available to you in solution of your current problems or in forward planning. We appreciate such opportunities to cooperate.

Adapters (Drive) • **Air Cleaners** • **Air Cleaners and Silencers** (Combination) • **Ammeters** • **Breathers** (Crankcase) • **Caps** (Radiator Pressure) • **Flexible Shaft Assemblies** • **Fuel Pumps** • **Fuel and Vacuum Booster Pumps** (Combination) • **Fuel Filters & Strainers** • **Gasoline Strainers** • **Gauges — Air** (Pressure) • **Gauges — Gasoline** • **Gauges — Oil** (Pressure) • **Gauges — Temperature** (Water, Oil) • **Oil Filters** (Lube) • **Panels** (Instrument) • **Reciprocating Vacuum Pumps** • **Rotary Vacuum Pumps** • **Spark Plugs** • **Speedometers** • **Tachometers** • **Terminals** (Ignition Wire) • **Valves** (Crankcase Ventilation)

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Insurance Center Building
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GM GENERAL MOTORS

AC SPARK PLUG — **THE ELECTRONICS DIVISION OF GENERAL MOTORS**

can you qualify for

Rocket Engineering?

*careers are being born right now at Rocketdyne**

It may surprise you to know you can do this *with or without specific rocket engine experience!* Engineering experience in heating and ventilating, hydraulics, pumps, turbines, combustion devices, controls and engine instrumentation are just a few of the related fields that could open your future at ROCKETDYNE.

At its new Canoga Park headquarters, ROCKETDYNE is continuing and expanding its pioneering work in the design, development and manufacturing phases of the rocket engine business. And at its test laboratory, ROCKETDYNE has complete research and test operations. ROCKETDYNE thus offers opportunities in the complete range of rocket engine development from preliminary design to field testing.

ROCKETDYNE not only offers the advantages of a constantly growing and expanding company, but also the stability that comes from its broad range and volume of projects... the stability of rocket engine contracts with all branches of the Armed Services and the guided missile industry. Though it is currently emphasizing the production of the most powerful large liquid-propellant rocket engines in the Western World, ROCKETDYNE is also designing, building, and testing many other types and sizes. For the future, it is carrying on research for even more powerful and startling rocket engines.

So this is your big opportunity to build a career that really has a future. A well-paid career that assures prestige, stability, and selectivity of fascinating work. If you feel you can qualify, you owe it to yourself to contact ROCKETDYNE today.

*ROCKETDYNE is North American's rocket engine division. It has just moved into new ultra-modern headquarters in Canoga Park, located in the beautiful West San Fernando Valley of Los Angeles. This area is famous for its fine residential sections, modern shopping-center convenience, varied recreational and entertainment facilities. Any point in the San Fernando Valley is just minutes drive from the beaches, and the weather is pleasant all year 'round. Many engineers are interested in advance schooling offered by UCLA, only ½ hour drive from our laboratory.

THESE POSITIONS NOW OPEN AT ROCKETDYNE:

DESIGN & DEVELOPMENT ENGINEERS
Mechanical, Chemical, Electrical, Standards, Structural and Stress. For rocket engine systems design or development. Turbine, pump, controls and combustion device experience preferred.

DYNAMICS ENGINEERS
To analyze rocket engine control systems utilizing electronic analog and digital computers, B.S., M.E., or B.S.E.E. necessary. Prefer advanced degree. Experience in servomechanisms, systems analysis desired.

COMPUTER APPLICATION ENGINEER
Application of automatic computers to investigate new methods of numerical analysis.

TEST ENGINEERS
Experienced on engine systems, combustion devices, turbines, pumps and engine instrumentation.

EQUIPMENT DESIGN ENGINEERS
Electrical, mechanical, structural, industrial. For design of facilities, specialized test, and handling equipment.

WEIGHT ENGINEERS
ELECTRONICS TECHNICIANS
SPECIFICATIONS ENGINEERS
ENGINEERING DRAWING CHECKERS

Write Mr. Grant Baldwin, Rocketdyne Engineering Personnel, Dept. 596-SAE, 6633 Canoga Ave., Canoga Park, California.

ROCKETDYNE®

A DIVISION OF NORTH AMERICAN AVIATION, INC.

more dependable starting *under all operating conditions*

"No Kick-Out" feature sets new standards in starting performance.

● Since the earliest days of the automotive industry Bendix* Starter Drives have been noted for reliable starting.

Now with the new and latest Bendix Folo-Thru Starter Drive, starting, even under the most adverse weather conditions, has been improved immeasurably.

Although this new Bendix Starter Drive is fundamentally similar to its illustrious predecessors, it is specially designed to follow through the weak explosions until the engine actually runs on its own power.

That's why cars, trucks and buses equipped with the Bendix Folo-Thru Drive are easier and quicker to start under all operating conditions.

*REG. U.S. PAT. OFF.

ECLIPSE MACHINE DIVISION OF Bendix AVIATION CORPORATION

ELMIRA, NEW YORK

Export Sales: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

Bendix folo-thru starter drive

costs less—*The new Folo-Thru Drive requires no actuating linkage and the less expensive solenoid may be placed in any convenient position. Results are lower installation costs and no adjustments. Complete detailed information is available on request.*

Bendix° Folo-Thru Starter Drive **Bendix° Automotive Electric Fuel Pump** **Stromberg° Carburetor**

You'll love our *wide-open, spacious* 4-Door Catalinas!

If you like your glamour in a great big package, prepare to lose your heart to our new 4-Door Catalinas—hardtop styling at its beautiful, luxurious, clear-vision best. And if you love performance that sends your spirits soaring, your heart is still in the right place.

Trigger-quick, satin-smooth, and loaded with power, the '56 Pontiac matches its smart distinction with the greatest "go"—*and the greatest safety*—ever engineered into a car. You're invited to prove it . . . today.

'56 STRATO-STREAK *Pontiac*

PONTIAC MOTOR DIVISION OF GENERAL MOTORS CORPORATION

Watson Bros. ...one of the world's largest...adds 65 Fuller ROADRANGER® Transmissions to Expanding Fleet

Performance of 720 Fuller Transmissions in service prompts selection of semi-automatic units.

Today, the Watson Bros. Transportation Co., Inc., of Omaha, Nebraska, is rated as fourth largest common freight carrier operation in the United States . . . with 2400 units transporting 2,200,000 shipments annually over 60,000,000 miles.

Watson Bros. has just added 65 new modern tractor units, including:

40 West Coast International diesels equipped with Fuller 10-speed R-95-C Semi-Automatic ROADRANGER Transmissions,

15 Diamond T's putting horsepower to work through Fuller R-950-C Semi-Automatic ROADRANGER Transmissions, and a fleet of

10 R-195 Internationals equipped with Fuller 8-speed R-46 Semi-Automatic ROADRANGER Transmissions.

The performance of 720 Fuller Transmissions already in service for the pioneer Omaha common carrier was a prime reason for specifying Fuller Transmissions in their new equipment.

L. E. Erlewine, Superintendent of Maintenance for Watson Bros. since 1932, puts it this way: "The design of the ROADRANGER allows us to operate tandem-drive axles in both 50-foot and 55-foot states. Because of the ROADRANGER design we get more traction, resulting in safer operation. We need no chains on ice, and pull away from rigs using chains on the same grade. The performance of the semi-automatic ROADRANGER *adds up* to longer engine life, easier shifting, faster average speeds and greater fuel economy."

Fuller Transmissions make shifting fast and easy . . . and let the driver select the ratio he needs at the *right* time to meet every varying condition of time, traffic and terrain.

FULLER MANUFACTURING COMPANY
TRANSMISSION DIVISION • KALAMAZOO, MICH.

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BOSCH FUEL INJECTION EQUIPMENT — SYMBOL OF WORLD RENOWN

BOSCH
GERMANY

The two millionth BOSCH Injection Pump has just come off the production lines. This jubilee is a striking demonstration of uninterrupted successful performance by a product ranking high among BOSCH's pioneering achievements. Only the creation of this pump made the quantity production of high-speed diesels practical at all. But the figure of two million BOSCH Injection Pumps is also the proud balance of a mass production involving more than 50,000,000 high-precision components. Together with the universally approved BOSCH diesel equipment such as nozzles, nozzle holders and filters, they are a visible expression of the proverbial

Dependability And Thoroughness

backing each individual BOSCH product

BOSCH AND THE DIESEL ENGINE ARE INSEPARABLE

EPA 155

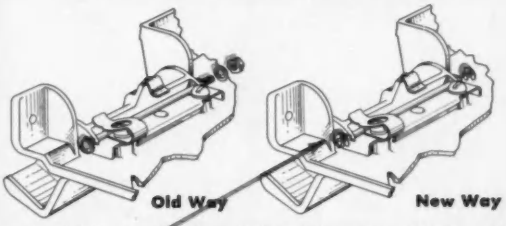
ROBERT BOSCH GMBH STUTTGART (GERMANY)

5 Waldes Truarc rings eliminate parts, speed assembly, in light, compact dictating machine

Edison's "V. P." Voicewriter

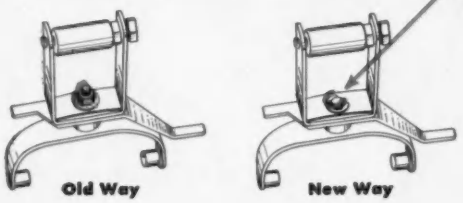
Edison engineers built this new dictating instrument for small size, light weight, and rugged performance. Waldes Truarc rings replace old fashioned fasteners, cut production costs; keep unit light, compact, and achieve faster more economical assembly.

Disc Lever Cover Assembly



Two Waldes Truarc E-Rings (Series 5133) replace nut, bolt, washer assembly, eliminate one component and assure precise alignment of parts. Truarc rings facilitate pivoting without binding. Production assembly time is decreased.

Lift Bracket and Fork Assembly



A single, easily assembled Waldes Truarc E-Ring (Series 5133) replaces nut-bolt-washer fastening. Free pivoting is assured, one component eliminated, labor and material costs reduced.

Clutch Plate Assembly

Two Truarc E-Rings eliminate staking operation, prevent damage to spring coil. Simple assembly operation speeds production, eliminates rejects, reduces labor and material costs.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today. Let our Truarc engineers help you solve design, assembly and production problems, without obligation.

For precision internal grooving and undercutting ...Waldes Truarc Grooving Tool!

WALDES
TRUARC®
RETAINING RINGS

Send for new catalog supplement

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
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SA-028

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

Rugged, high-powered

Sturdy, dependable Model B Tournapull, made by LeTourneau-Westinghouse Company, Peoria, Ill., works in all underfoot conditions without stalling. This 23-yard-capacity, 30-ton-load unit uses reliable Bundyweld Steel Tubing for fuel and air lines—eight parts in all, totaling 59′ 5″.

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

← NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

earthmover depends on extra-strong Bundyweld

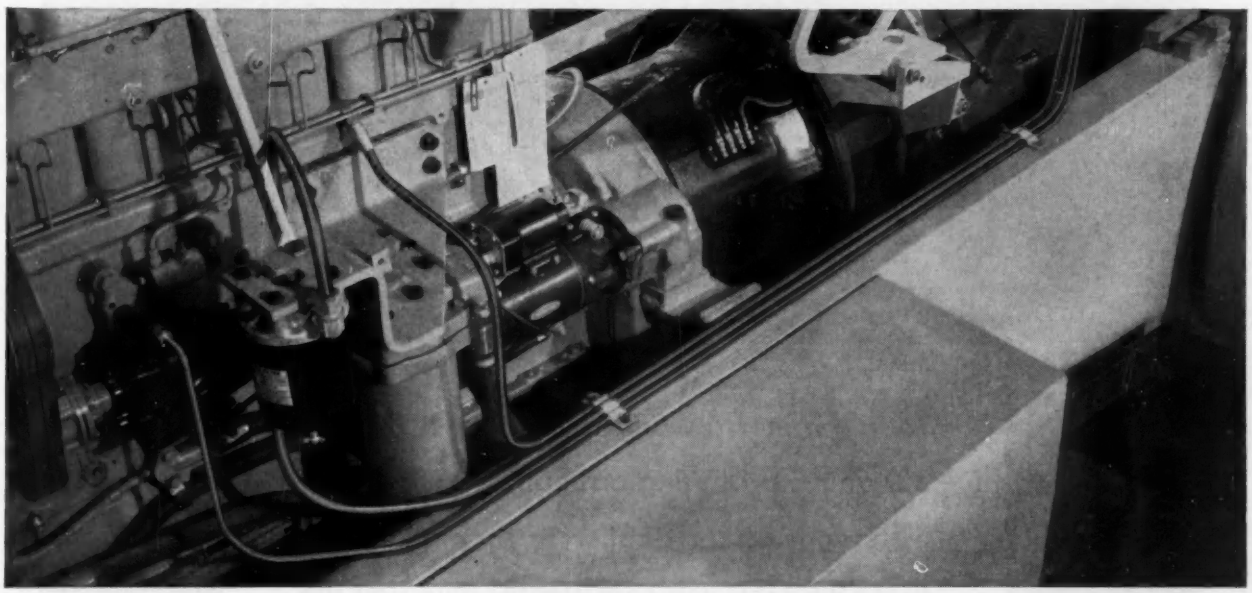
A familiar sight on highway projects across the nation, the Model B Tournapull works through all kinds of weather and surface conditions without difficulty.

The manufacturers of this rugged, high-powered earthmover naturally insist that all its component parts be *extra*-dependable, *extra*-reliable. That's why they specify sturdy Bundyweld Steel Tubing for vital fuel and air lines.

Remember, when dependability *counts*, you can count on Bundyweld. Bundyweld is leakproof by test; thinner walled, yet stronger; is remarkably resistant to vibration fatigue; has high bursting strength. It's the only tubing double walled from a single metal strip, copper-brazed throughout 360° of double-walled contact.

Bundy backs up its unexcelled tubing with the finest fabrication services; with expert engineering know-how and technical assistance; with custom-packaging of orders, on-schedule deliveries. In addition, our engineering staff *enjoys* finding solutions to tricky tubing problems. Call, write, or wire us about your particular headache.

BUNDY TUBING COMPANY • DETROIT 14, MICH.

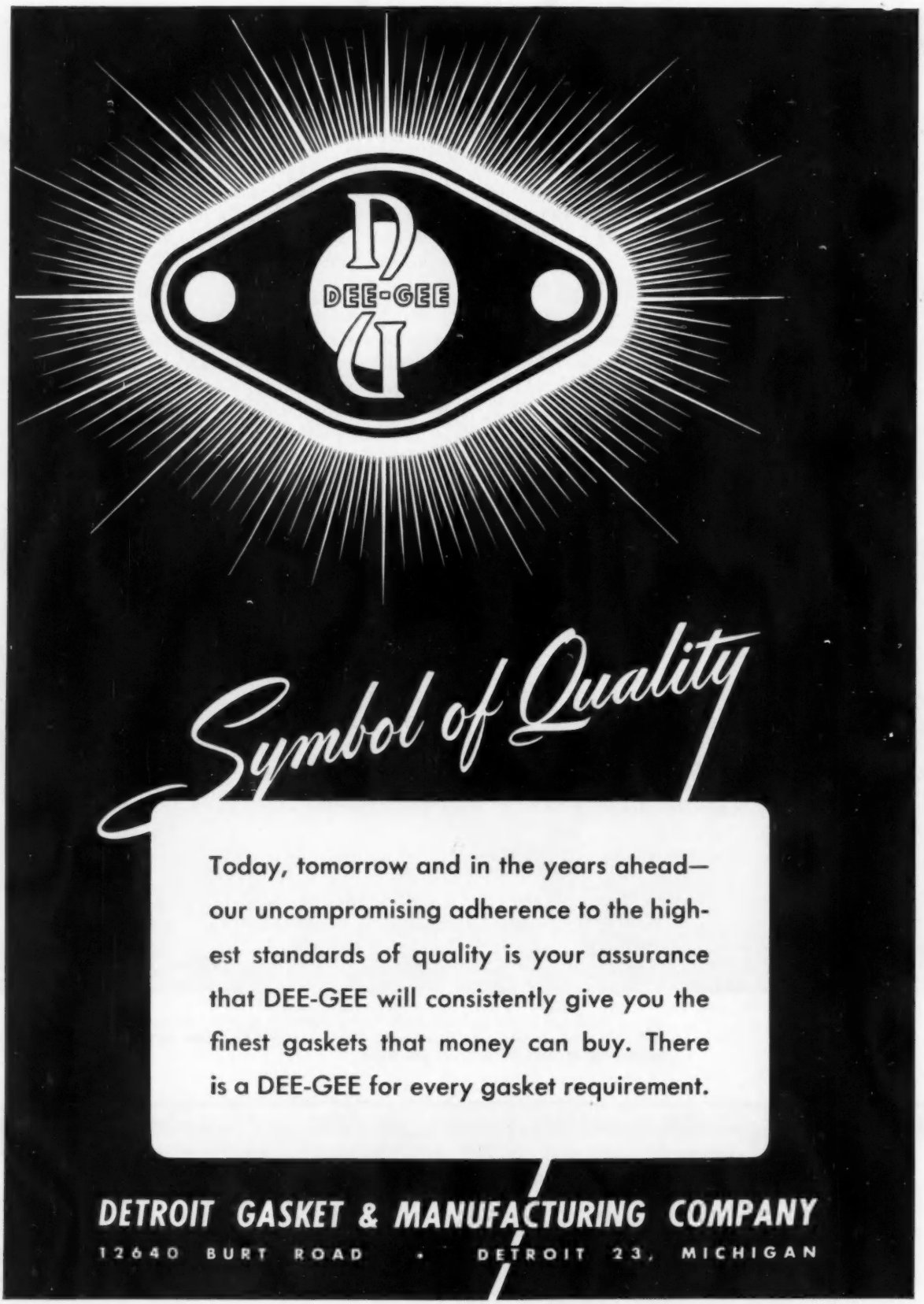


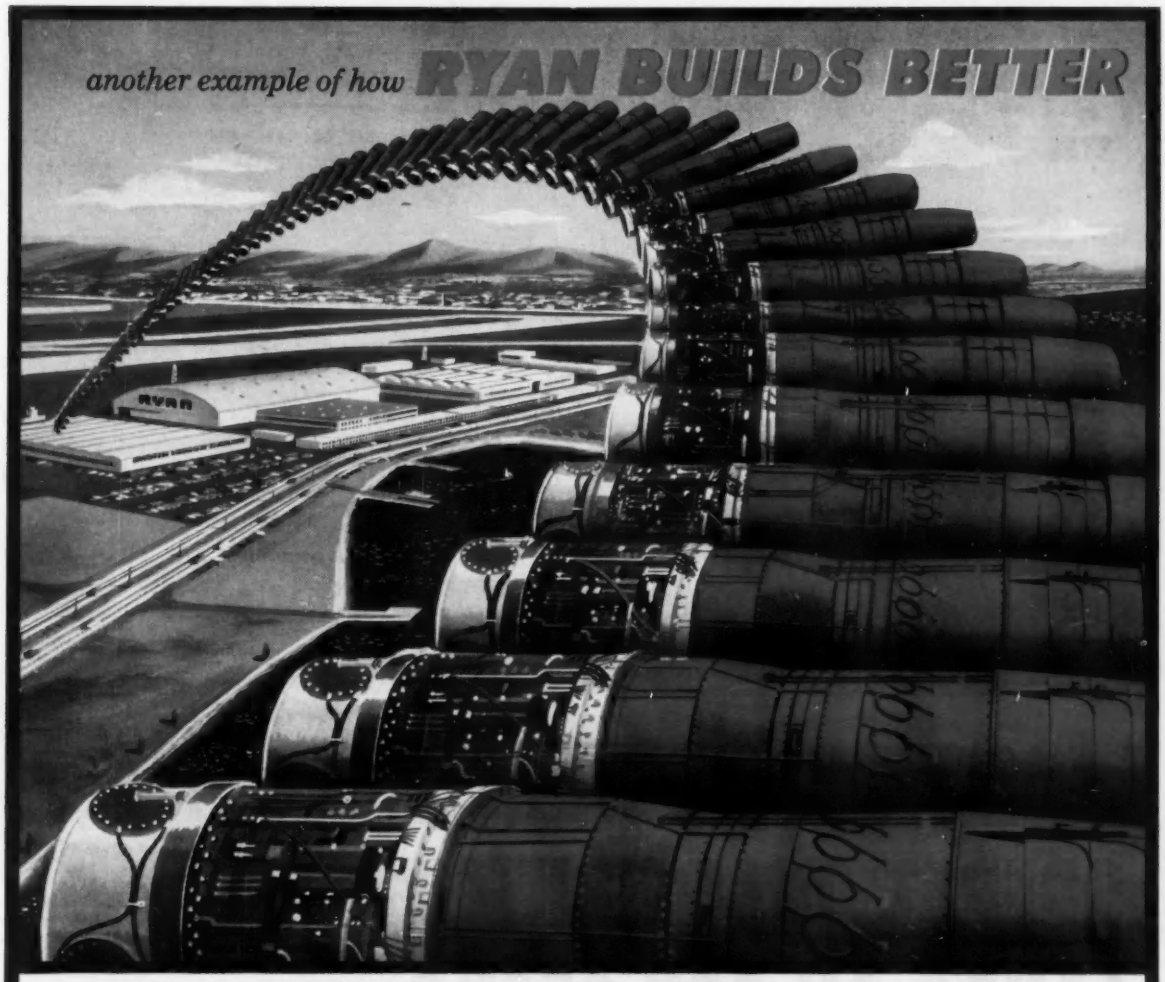
Above, engine of Model B Tournapull during assembly process, showing fuel and air lines of Bundyweld. Dependable Bundyweld Tubing helps keep these powerful earthmovers functioning at top efficiency, *all the time*.

BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP

Bundy Tubing Distributors and Representatives: ***Cambridge 42, Mass.:*** Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey:*** A. B. Murray Co., Inc., Post Office Box 476 • ***Los Angeles 58, Calif.:*** Tubesales, 5400 Alcoa Ave. • ***Philadelphia 3, Penn.:*** Rutan & Co., 1717 Sansom St. • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** Eagle Metals Co., 4755 First Ave., South ***Toronto 5, Ontario, Canada:*** Alloy Metal Sales, Ltd., 181 Fleet St., E. • **Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.**


DEE-GEE
Symbol of Quality
Today, tomorrow and in the years ahead—our uncompromising adherence to the highest standards of quality is your assurance that DEE-GEE will consistently give you the finest gaskets that money can buy. There is a DEE-GEE for every gasket requirement.
DETROIT GASKET & MANUFACTURING COMPANY
12640 BURT ROAD • DETROIT 23, MICHIGAN



QUALITY HOT PARTS FOR MORE U. S. JETS

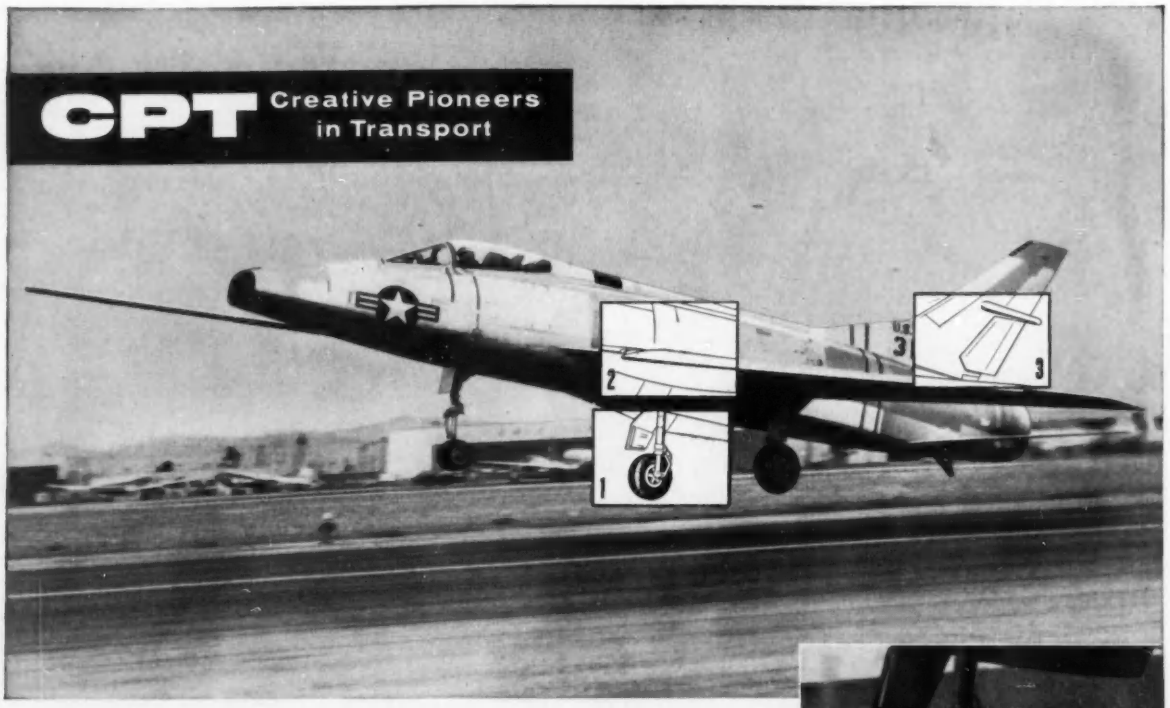
Two-thirds of America's newest, fastest models of Air Force and Navy combat aircraft depend upon Ryan jet engine components. From its modern 43-acre plant Ryan delivers these precision-built, high-temperature assemblies to the major jet engine manufacturers, who produce the power plants for America's defense armada.

Jet engine builders look to Ryan's Metal Products Division for "hot parts" because it has specialized for 20 years in designing and producing these complex high-temperature structures. Ryan is uniquely skilled and equipped to build the first experimental units of difficult designs and then streamline these prototype designs for efficient low-cost, volume production of the final models.

In addition to "hot parts" for turbojets and afterburners, this major division of Ryan also produces powerful rocket motors and a wide range of components for ramjets, turbo-compound and piston engines.

For 33 years, Ryan has excelled in designing and producing high quality aircraft, power plants and avionics—built at low cost, delivered on time.

RYAN
AERONAUTICAL COMPANY
SAN DIEGO 12, CALIFORNIA



F-100 WORLD'S FASTEST OPERATIONAL FIGHTER LANDS ON CPT GEARS

The "Super Sabre" gets off to work on CPT landing gears . . . and they bring her safely down to earth again.

North America's F-100, world's first operational supersonic fighter, has nose and main landing gears built by CPT (Cleveland Pneumatic).

The F-100 also has a unique steel fin beam assembly fabricated by CPT, using the world's largest flash-butt welder and our giant heat-treating and machining facilities.

No other producer of landing gears has the background of experience and the complete facilities to be found at CPT.

Pioneer in landing gear development since 1926, CPT has produced more landing gears than any other manufacturer.

Put CPT's experience and plant to work on *your* next project . . . a CPT sales engineer will call at your convenience.

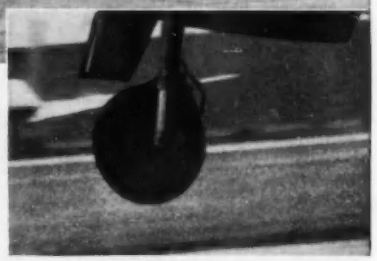
CPT

CLEVELAND PNEUMATIC

TOOL COMPANY • Dept. K-256 • Cleveland 5, Ohio

Sales offices in Seattle, Los Angeles, Fort Worth-Dallas, and Levittown, L. I.

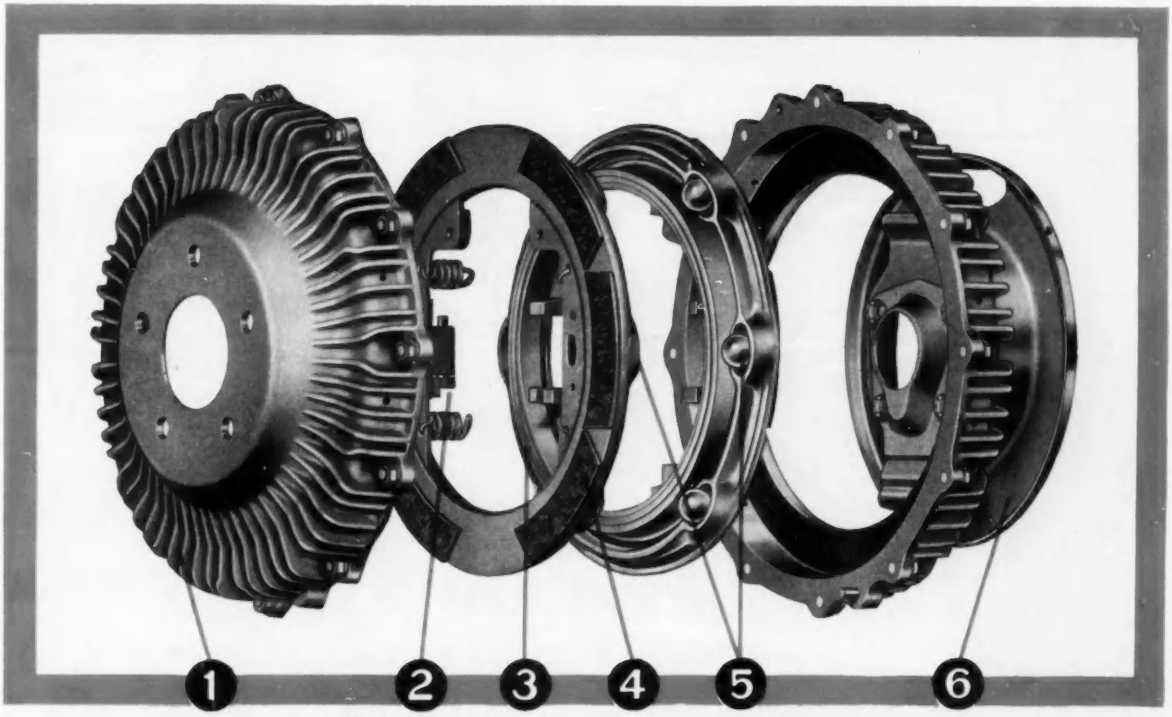
CPT...world's largest and most experienced builder of landing gears and ball-screw mechanisms



1 LANDING GEARS—Nose and main landing gears on many of today's fastest fighters are built by CPT, using aluminum and high alloy steel.

2 ACTUATORS—Wing flaps, landing gears, and rudder trim controls on leading aircraft are operated by CPT ball-screw mechanisms and actuators.

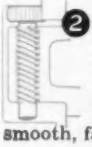
3 FIN BEAMS—High-strength, lightweight fin beams are made by CPT, using the world's largest flash-butt welder for assembly.



Double-Disc Brakes Are Safer Brakes... *Here's Why...*

Each Ausco "Double-Disc" Brake is really two brakes within one housing. The primary disc and outer housing make one brake; the secondary disc and inner housing, another. Both brakes use the same actuating and self-energizing systems.

❶ The finned housings are of aluminum and have a large surface area to dissipate heat rapidly and enable the brake to run cool. Even the heat generated by repeated panic stops does not distort or warp Double-Disc Brakes—or cause "fade" as is the case with conventional brakes. Ausco Brakes are safer brakes.



❷ Double-Disc Brakes *automatically* stay in adjustment. Thus, pedal height is constant and braking is uniform. During the life of the brake, the adjuster (2) maintains proper clearance between the lining on the discs and the bearing surfaces. These brakes are therefore *always* effective. Stops are smooth, fast, without dangerous swerving or grabbing.

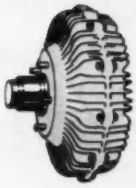
❸ The Double-Disc Brake is hydraulically actuated. Braking action is started by pressure on the foot pedal acting through hydraulic fluid to move the annular piston (3). This piston forces the two actuating discs apart. Contact is made between the brake lining and the friction areas. Then the momentum of the car rotates the primary disc in relation to the secondary disc and the Auto Specialties self-energization principle goes into operation.

❹ The outer surfaces of the discs carry segments of heavy-duty organic brake lining. 100% of the lining contacts the friction surfaces of the housings. Ausco Brakes have a large area of braking surface, work at lower pressures, and have longer lining life. Therefore, you stop surer, safer, smoother with Auto Specialties Double-Disc Brakes.

❺ Auto Specialties' ball-and-ramp construction is the heart of the self-energization principle. The car's momentum causes the balls to roll up the ramps. This further separates the discs, forcing the lining tighter against the bearing surfaces. The greater the momentum, the greater the braking power. Self-energization and pedal pressure each supply half the total braking force. Pedal pressure is, therefore, light. Ausco Disc Brakes require no costly external booster system.

❻ Mounting plates are attached to the front spindles and to rear axle housing. This is the stationary element of the Auto Specialties Double-Disc Brake and it absorbs all the torque. The flange mates with a groove on the inner housing to make the brake splash-proof. Auto Specialties Brakes give you better, safer braking under all road and weather conditions.

Auto Specialties Mfg. Company offers this brake with the full knowledge that it has been proved superior and fully meets the requirements of modern driving.



AUTO SPECIALTIES MFG. CO., INC.

SAINT JOSEPH, MICHIGAN

Plants also at Benton Harbor and Hartford, Mich., and Windsor, Ont., Canada.

Manufacturing for the automotive and farm machinery industry since 1908.

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here's how to get the right heater, too!

Call on Evans. Our engineers will design your truck heater—as you design your truck chassis—to meet the special requirements of the job.

Your Evans heater will be right for your truck in *every* way! It will fit right . . . for quick, easy installation. It will deliver the right BTU output . . . provide maximum safety and comfort for the driver under *any* weather conditions. And it will give many added years of service—thanks to Evans' special, heavy-duty continuous-service motor, one-piece alloy fan, and sturdy fin and tube type core—all perfectly teamed to give trouble-free, low-cost operation.

For the full story on Evans heating and ventilating systems and what they can do for you, write for a copy of the new Evans Heater Catalog . . . or better still, phone or write to have an Evans engineering consultant call on you, at no charge. Evans Products Company, Department Z-2, Plymouth, Michigan.

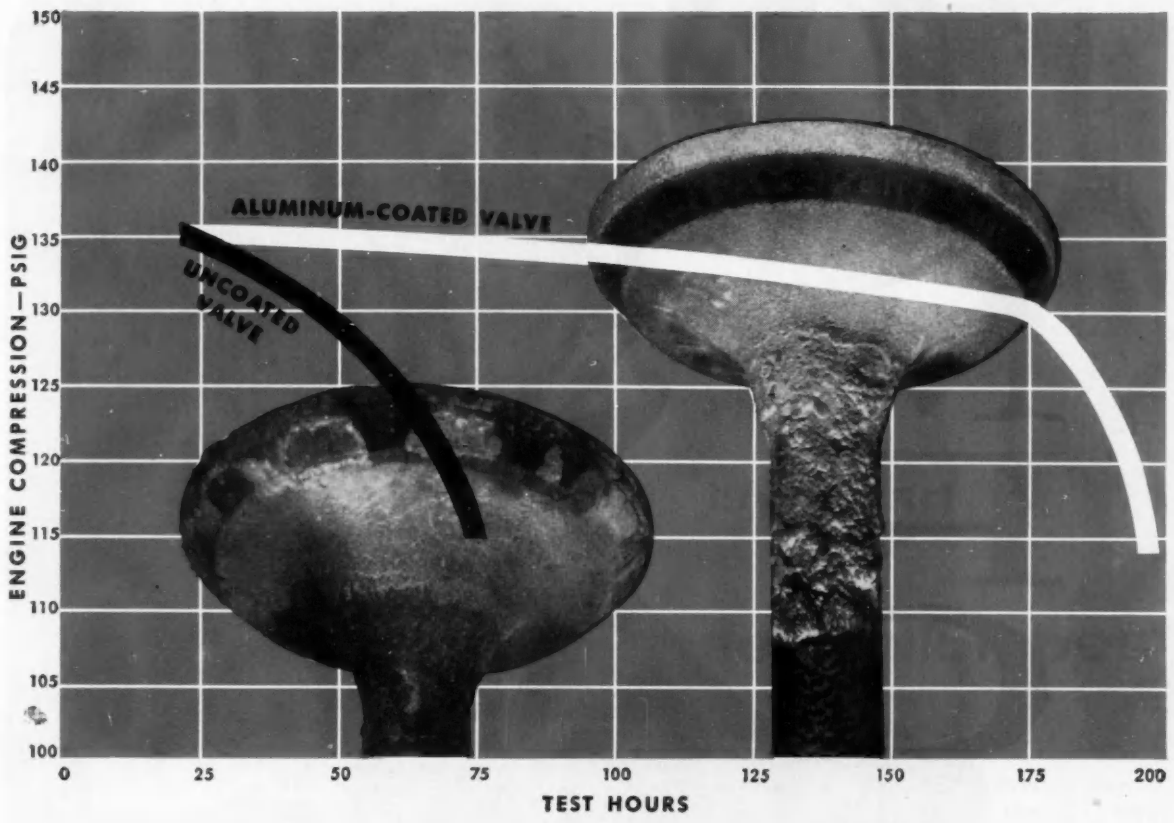
REGIONAL REPRESENTATIVES: Cleveland, Frank A. Chase • Chicago, R. A. Lennox Co., Inc. Detroit, Chas. F. Murray Sales Co. • Allentown, Pa., P. R. Weidner

EVANS HEATERS AND VENTILATORS

. . . Complete truck and bus systems . . . built right for the job

186% longer life

with Thompson Aluminum-Coated Valves



Here's a long-lasting remedy for reduced valve life caused by corrosion... the Thompson method of coating exhaust and intake valves with aluminum.

Tests show that Thompson aluminum-coated valves last up to 186% longer than uncoated valves under identical conditions.

The Thompson process of applying aluminum to the valve assures penetration of the steel by the corrosion-resistant aluminum. This provides protection of the valve face from erosion by hot gases and corrosive agents from combustion.

Thompson sales engineers are prepared to discuss aluminum coating of exhaust and intake valves for your engines. Write today for information and engineering data.

Valve Division Thompson Products, Inc.

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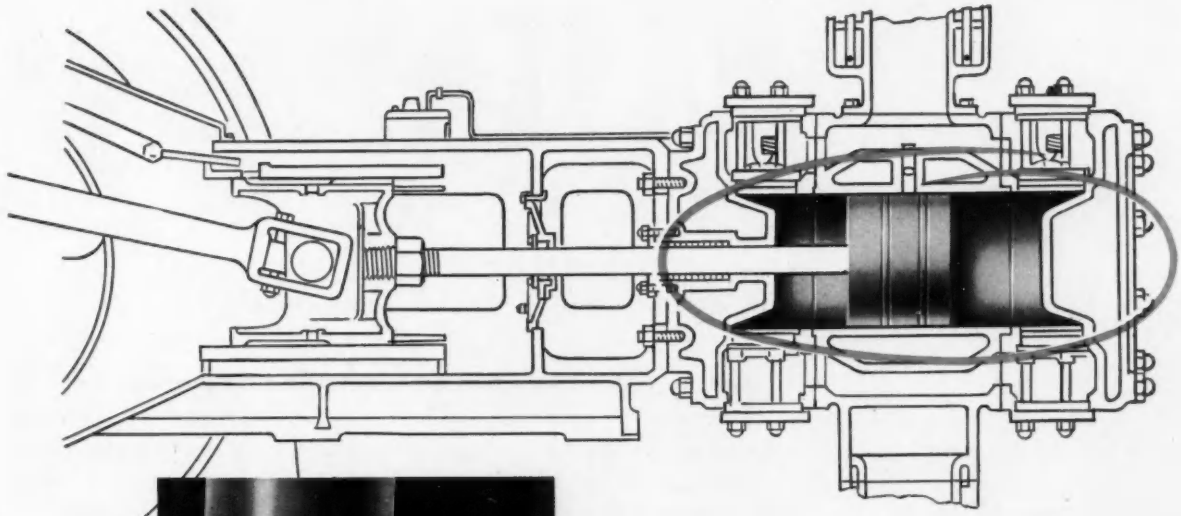
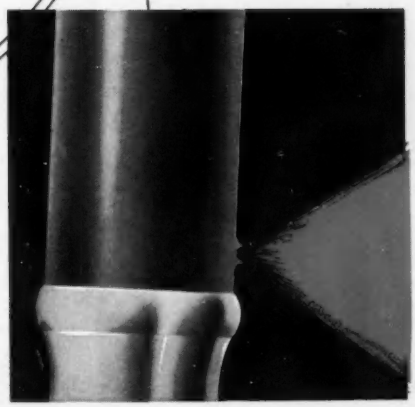
Factories: JAMESTOWN, N. Y. • PLAINVILLE, CONN. • FALCONER, N. Y.





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Synthetic lubricants and power transfer fluids are now available in 6 controlled viscosities

Celanese Cellulubes are fire-resistant synthetic oils, designed to provide protection against fire hazards and explosion inherent in many industrial operations.

As air cylinder lubricants in compressed air systems, Cellulubes prevent the formation of excessive carbon deposits—No. 1 source of compressor fires and explosions. They are excellent lubricants—highly stable, non-corrosive, non-foaming.

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With the expansion of the Cellulube series to 6 controlled viscosities: 90, 150, 220, 300, 550, and 1000 (S.U.S. @ 100° F.), the way is open to replace flammable fluids in many hazardous applications. If you would like to evaluate Cellulube in your own operation, use coupon below to order working samples and complete use data. Celanese Corporation of America, Chemical Division, Dept. 598-B, 180 Madison Avenue, New York 16, N. Y.

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Please send me working sample and technical bulletin on Cellulube for air compressor service____ for hydraulic systems____. Send technical representative____.

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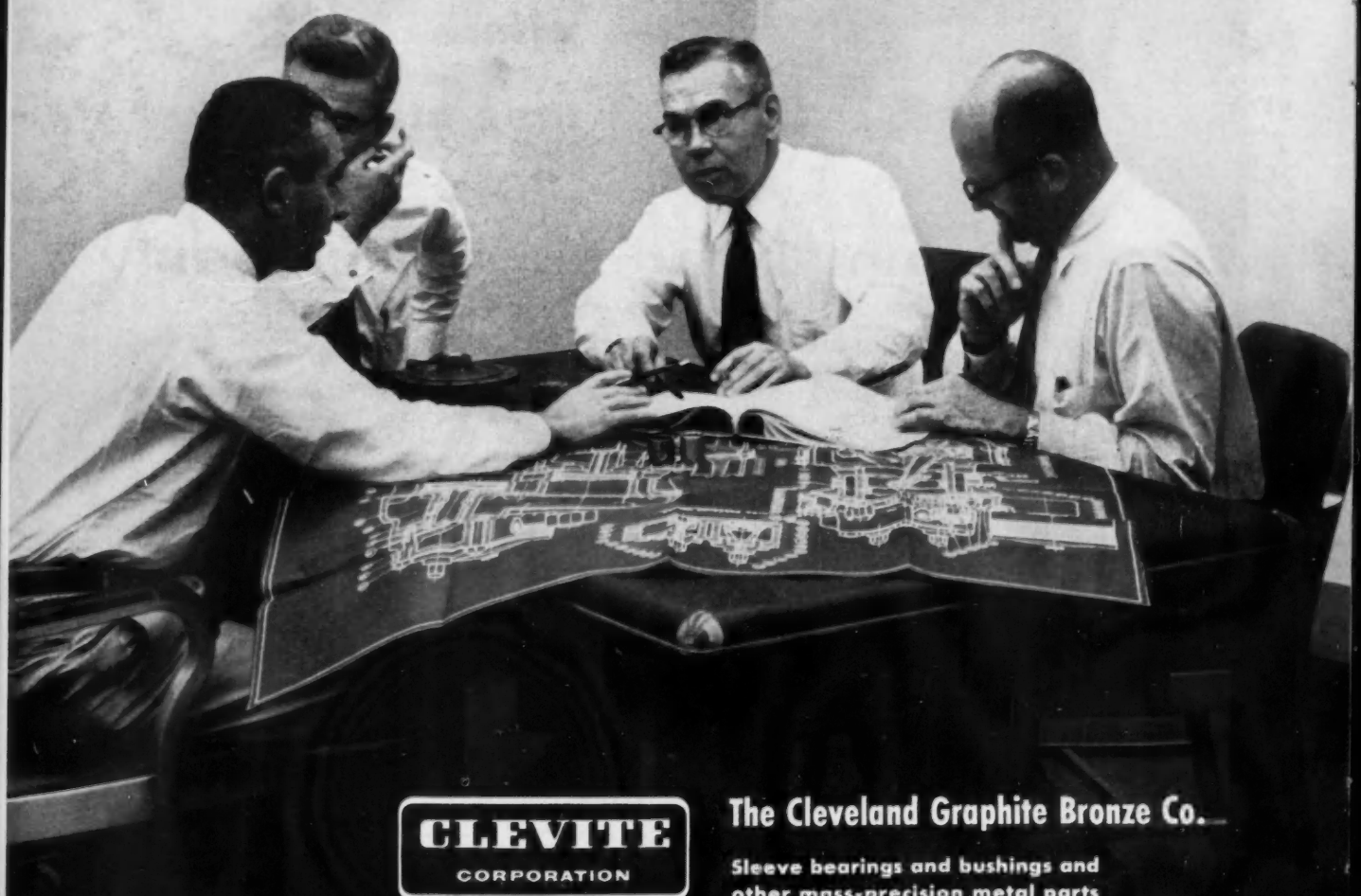
You get *something extra* when you call in Cleveland Graphite Bronze

Cleveland Graphite Bronze has become the leading maker of sleeve bearings and bushings because of the "extras" we give our customers.

One extra we give our customers is ***outstanding engineering:*** fundamental research at the Clevite Research Center; original thinking at the design stage; searching thoroughness in testing and development. To follow through, we have a fast, able team of field engineers, working on specialized problems in our customers' plants.

With this concentration on engineering, we have introduced almost all the real improvements in our industry in the past 35 years, and have put them to work for the leading manufacturers in half a dozen different fields.

C. G. B. customers are getting the best advice, and getting it first. Are you missing out on it?



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The Cleveland Graphite Bronze Co.

Sleeve bearings and bushings and other mass-precision metal parts

now available to the die casting industry

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Nelmor presents the first practical, production-proven, vacuum die-casting process... to produce zinc castings of quality and uniformity never before attained at normal operating speeds. The Nelmor Vacaloy Process drastically reduces porosity... improves surface finish... and increases skin density. Castings require less surface preparation for plating... offer higher corrosion resistance. Hardness and tensile strength are greatly increased... metal and die costs, scrap loss, and rejects are reduced. NO CHANGES NECESSARY ON YOUR PRESENT DIES! Nelmor will furnish equipment and engineering service to convert your machines to this process at a nominal cost... or new machines can now be purchased already Vacaloy-equipped.

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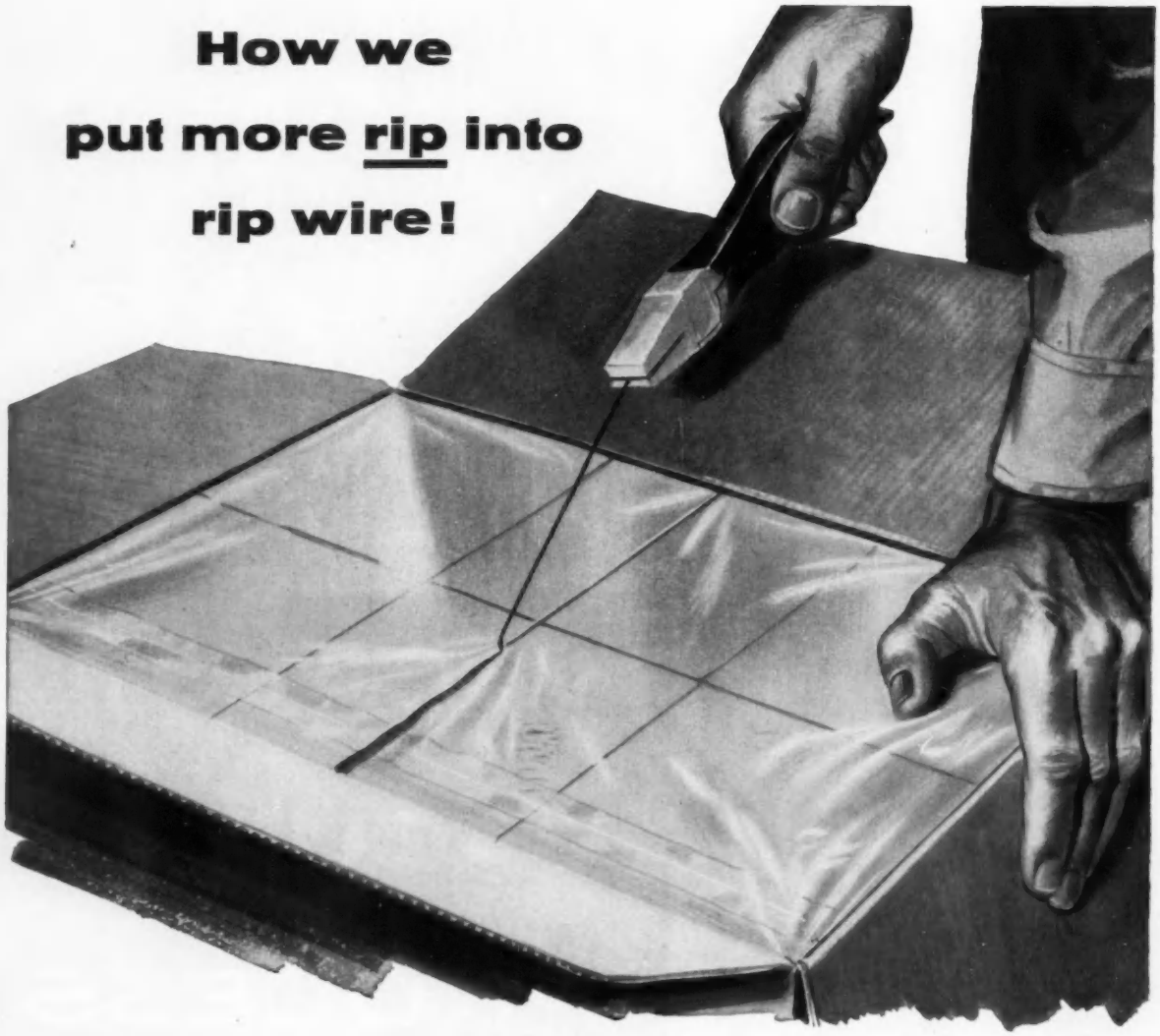
How we put more rip into rip wire!



● Industry often wraps its products in heavy paper to protect it from damage due to moisture, handling and other causes. To make these packages or bundles easier to open, *Worcester Wire Works* has developed a special rip wire for inclusion in the wrapping.

To get even greater protection, some products are wrapped in plastics rather than paper. And this caused a problem. Ordinary rip wire wouldn't cut the tough plastic.

Our *Worcester Wire Works Division* solved the problem by developing a special rip wire with a knurled surface that literally put teeth into the wire. It cuts through the toughest plastic coating as easily as a buzz saw.

Not all of the problems we solve for industry have such simple solutions. Often, we are called upon to develop steel and wire with completely new characteristics . . . to combine seemingly incompatible factors or properties. And quite frequently these are developments that other manufacturers have given up on.

If you have a problem calling for special development work in steel or wire . . . either in creating a product or finding new and better ways to make or use it . . . it will pay you to write or call National-Standard.

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What size is a quality fastener?

Here are two ELASTIC STOP® nuts.
Each has the familiar red locking collar. Each is self-locking, vibration-proof and can be reused many times. Each is a fast, readily assembled one-piece unit . . . will maintain accurate adjustment anywhere on a bolt. Each will afford positive protection against thread corrosion . . . prevent liquid seepage along bolts. Each is manufactured in quantity. Each is exactly controlled as to quality of raw material, finished dimensions, class of thread fit, seat squareness and finish. Each has a record for precision and uniformly high performance that is unmatched.

But . . . one measures 1/10 inch across the flats; the other, 4 inches. Between these two, there are more than 530 different hex nuts in the ESNA line. They are the result of variations in height, material, finish and size.

Look to ESNA for the top quality self-locking fastener that fits your need best.

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA® TRADE MARK

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Elastic Stop Nut Corporation of America®
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Please send the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

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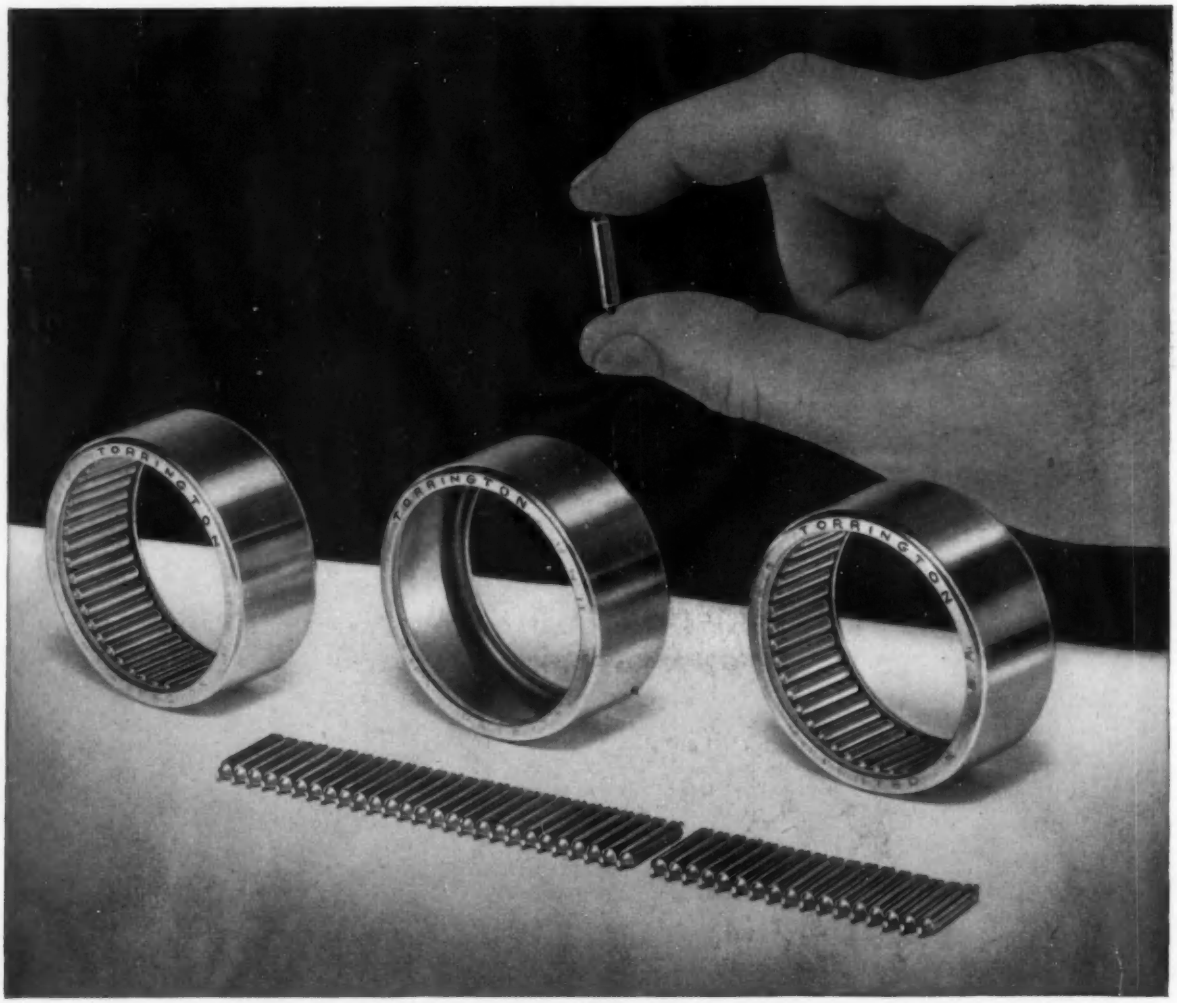

Here's where the **TORRINGTON NEEDLE BEARING** *gets its precision*

This Needle Roller is the "work horse" of the Torrington Needle Bearing. Its jewel-like precision is the key to smooth performance of the Needle Bearing. That's why in every manufacturing step—from alloy selection to final polishing—the rollers are checked against strict quality controls.

A full complement of Needle Rollers, mounted in a precision-made, case-hardened retaining shell, provides a maximum number of contact lines, giving the Torrington Needle Bearing a higher radial load capacity than any other bearing of comparable size.

The Torrington Needle Bearing delivers top anti-friction performance—with low coefficient of both starting and running friction.

For more than twenty years, our Engineering Department has helped designers and manufacturers throughout industry to adapt the unique advantages of the Needle Bearing to their products. Let us help you make the Needle Bearing "standard equipment" in yours.

See our new Needle Bearing Catalog in the 1956 Sweet's Product Design File —or write direct for a catalog.

TORRINGTON NEEDLE BEARINGS
Give you these benefits

- low coefficient of starting and running friction
- full complement of rollers
- unequalled radial load capacity
- low unit cost
- long service life
- compactness and light weight
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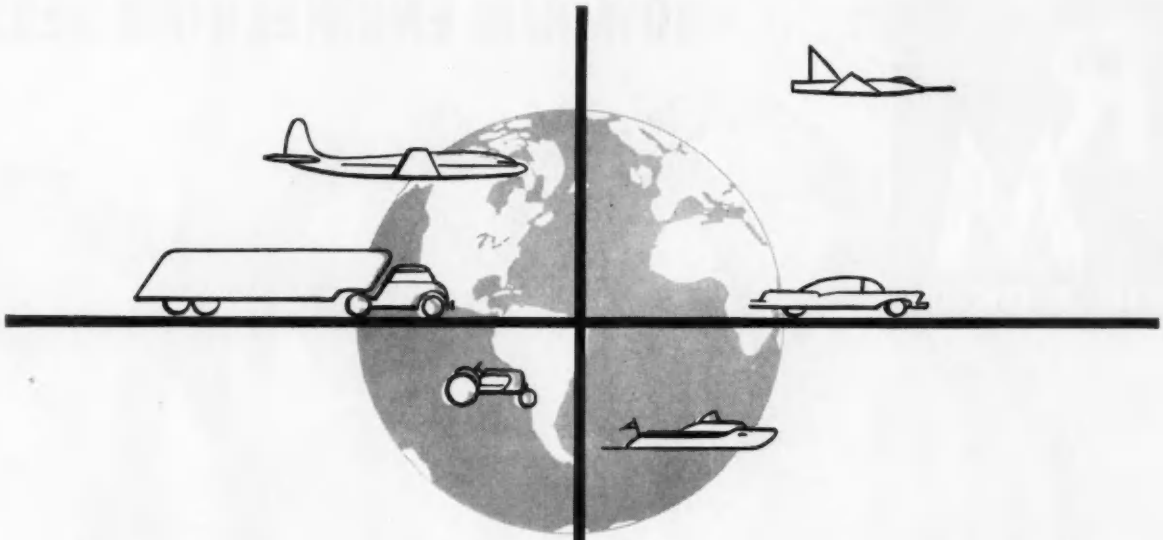

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THE ELECTRIC AUTO-LITE COMPANY
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R/M

FIRST IN FRICTION

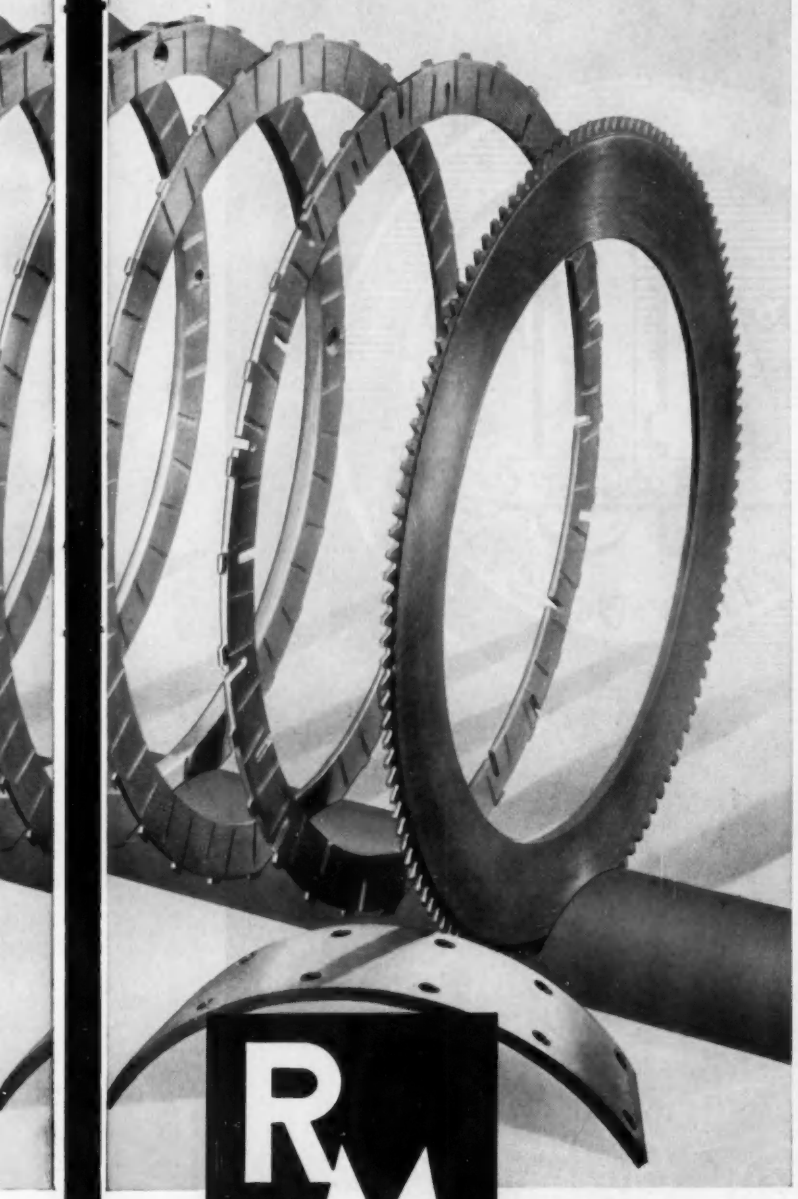
HOW R/M ENGINEERING SETS

The sintered metal clutch facings, discs, brake linings, and other friction parts pictured here suggest the wide variety of sizes and types that Raybestos-Manhattan, for over 50 years the world's largest maker of friction materials, is manufacturing for specialized applications. The exclusive, patented "metallo-ceramic" bond used by R/M in sintered metal friction materials produces a compound distinctly superior to the common straight alloy bond of copper and tin.

THE RECORD OF "FIRSTS" IN FRICTION MATERIAL DEVELOPMENT SHOWS WHY R/M IS FIRST IN FRICTION

FIRST Woven Brake Lining • FIRST Asbestos Brake Lining • FIRST Ground Wearing Surface • FIRST Zinc Alloy Wire Brake Lining • FIRST Pre-Treated Yarns • FIRST Extruded Pulp Brake Lining • FIRST Flexible Pulp Brake Lining in Rolls • FIRST Dry Process Brake Lining • FIRST Semi-Metallic Brake Lining • FIRST Bonded-to-Metal Brake Lining • FIRST Woven Clutch Facings • FIRST Molded Asbestos Clutch Facings for Clutches Operating in Oil FIRST Endless Woven Clutch Facings • FIRST Pre-Treated Clutch Facings • FIRST Bonded-to-Metal Clutch Facings

THE PACE IN FRICTION MATERIAL DEVELOPMENT



SINTERED METALS

Do you have a friction material application where high temperatures and close tolerances are factors? Or where friction components must be held to a minimum thickness? If so, Raybestos-Manhattan Sintered Metal friction parts may be an exact answer to your problem.

R/M full sintered friction materials are best described as matrices of sintered metal mechanically entrapping both metallic and non-metallic friction-augmenting agents.

Speaking generally, they are most useful where K.E. absorption per square inch of friction material is very high. Or where engagements occur on a repetitive cycle with little time interval. Under such severe conditions, organic-content materials wear at an accelerated rate. R/M Sintered Metals will perform without appreciable increase in wear rate because of their high thermal conductivity and the absence of a destructible bond.

The work done and heat generated by friction material are a function of the pressure involved. A reasonable working range for asbestos materials in dry operation is 25-100 psi. With sintered metal friction material you may go as high as 400 psi.

R/M Sets the Pace
in Both the Metal and Asbestos Fields

Raybestos-Manhattan Sintered Metal compounds are designed to meet a distinct and special group of application requirements. They are intended to *supplement* asbestos molded and woven lines—not replace them.

That is why R/M—the leader in both the asbestos and metal fields—is in a unique position to help original equipment manufacturers. Unlike other makers in its field, R/M works with all kinds of friction materials—from woven and molded asbestos to cork-cellulose, semi-metallic, and sintered metals. When you consult an R/M engineer, you can be sure of a *completely unbiased recommendation* as to which friction materials are best suited for your particular application.

If you are looking for friction materials with greater output and durability, call in your R/M representative. The full depth and breadth of R/M experience—the complete facilities of R/M's seven great plants with their research and testing laboratories—are at your disposal to either develop a special material for your requirements or suggest how you can redesign to make effective use of an R/M material already on hand.

Write for your free copy of R/M Bulletin No. 500. Its 44 pages are loaded with practical design and engineering data on all R/M friction materials.

R M
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THE TRADE-MARK THAT SPELLS PROGRESS IN FRICTION MATERIAL DEVELOPMENT

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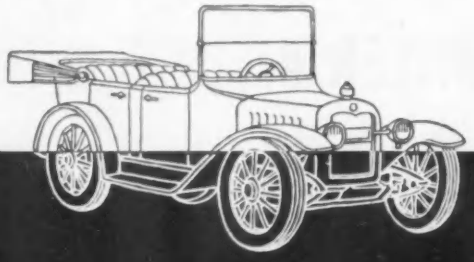

Aetna

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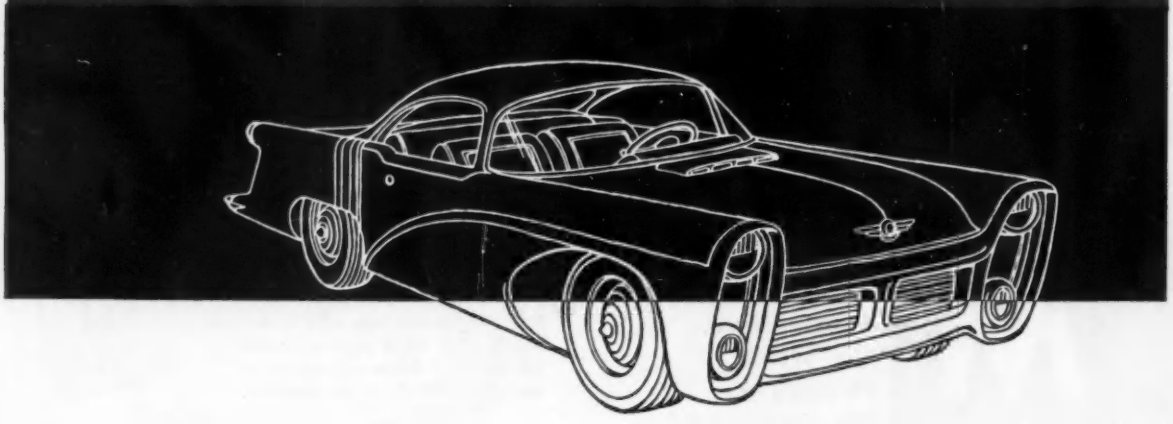
YEARS

FIGHTING FRICTION

BALL BEARINGS • ROLLER BEARINGS • PRECISION PARTS



AETNA BALL AND ROLLER BEARING COMPANY

DIVISION OF PARKERSBURG-AETNA CORPORATION • 4602 SCHUBERT AVENUE • CHICAGO 39, ILLINOIS

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Proven in Operation to Offer . . .

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Simmonds Aerocessories, Inc., manufactures the only advanced type fuel injection system now in production in the U.S. for reciprocating engines up to 600 h.p. After extensive field tests on U.S. ordnance engines (where fuel economies of more than 20% were proven) SU Fuel Injection Systems are also being specified on a growing list of medium-range aircraft and helicopter engines.

Other proven advantages of the SU Fuel Injection System:

- **Overcomes major icing problems; gives improved cold starts.**
- **Eliminates the need of hot-spots and pre-heaters; simplifies manifold ducting.**
- **Provides increased power output due to removal of intake obstructions.**
- **Provides improved fuel distribution and better cylinder head cooling.**
- **Operation not affected by engine attitude.**

Complete data on SU Fuel Injection Systems available on request.

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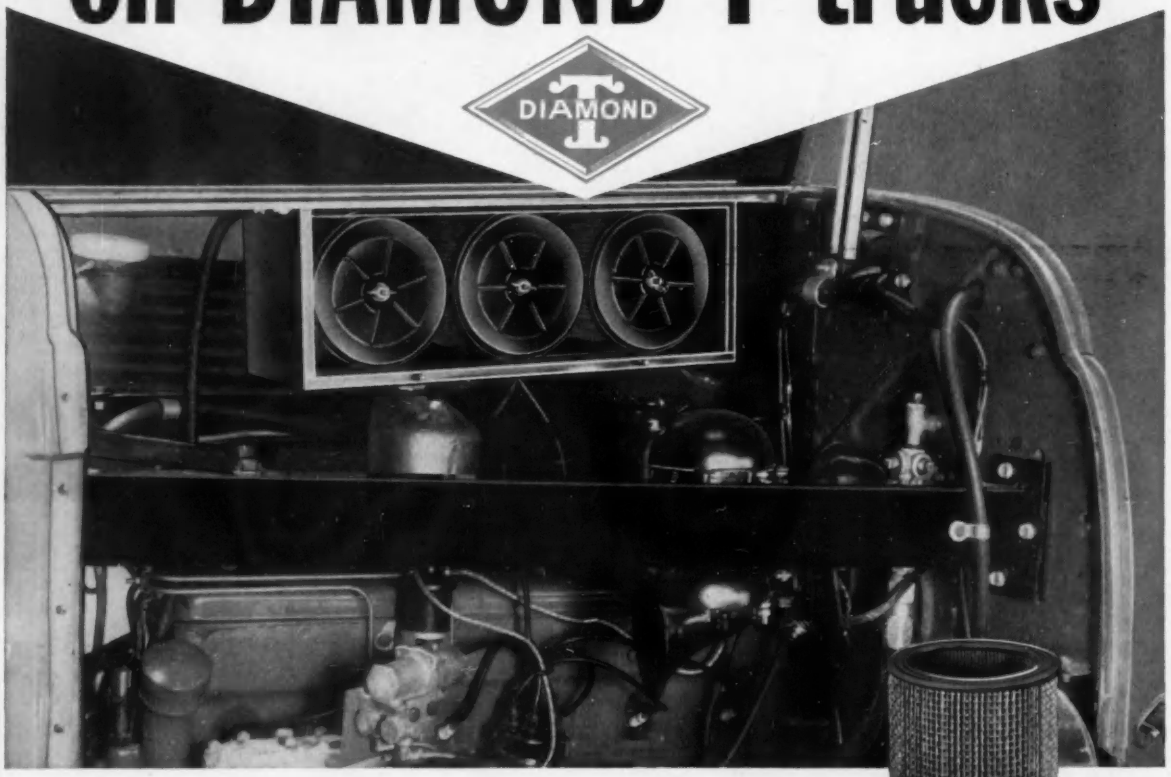
FRAM Air Filters
now standard equipment on DIAMOND T trucks

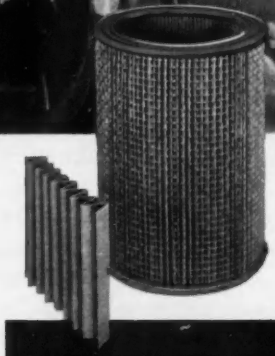


3 FRAM Super Kleen Carburetor Air Filters— 99.5% efficient—cut engine wear, guard power

Now famous Diamond T truck engines enjoy the protection of FRAM Carburetor Air Filters, to preserve power, reduce wear and lengthen life. FRAM will safeguard these Diamond T engines even under the most severe dust conditions.

The FRAM Carburetor Air Filter is the most advanced method of air filtration. It retains high filtering efficiency throughout long life and its low-cost replacement cartridge can be serviced in less than a minute!

FRAM Super Kleen Carburetor Air Filters on your vehicles will cut down-time, add extra miles and pay off in profit. So for your own satisfaction, and your customers' satisfaction, specify FRAM!



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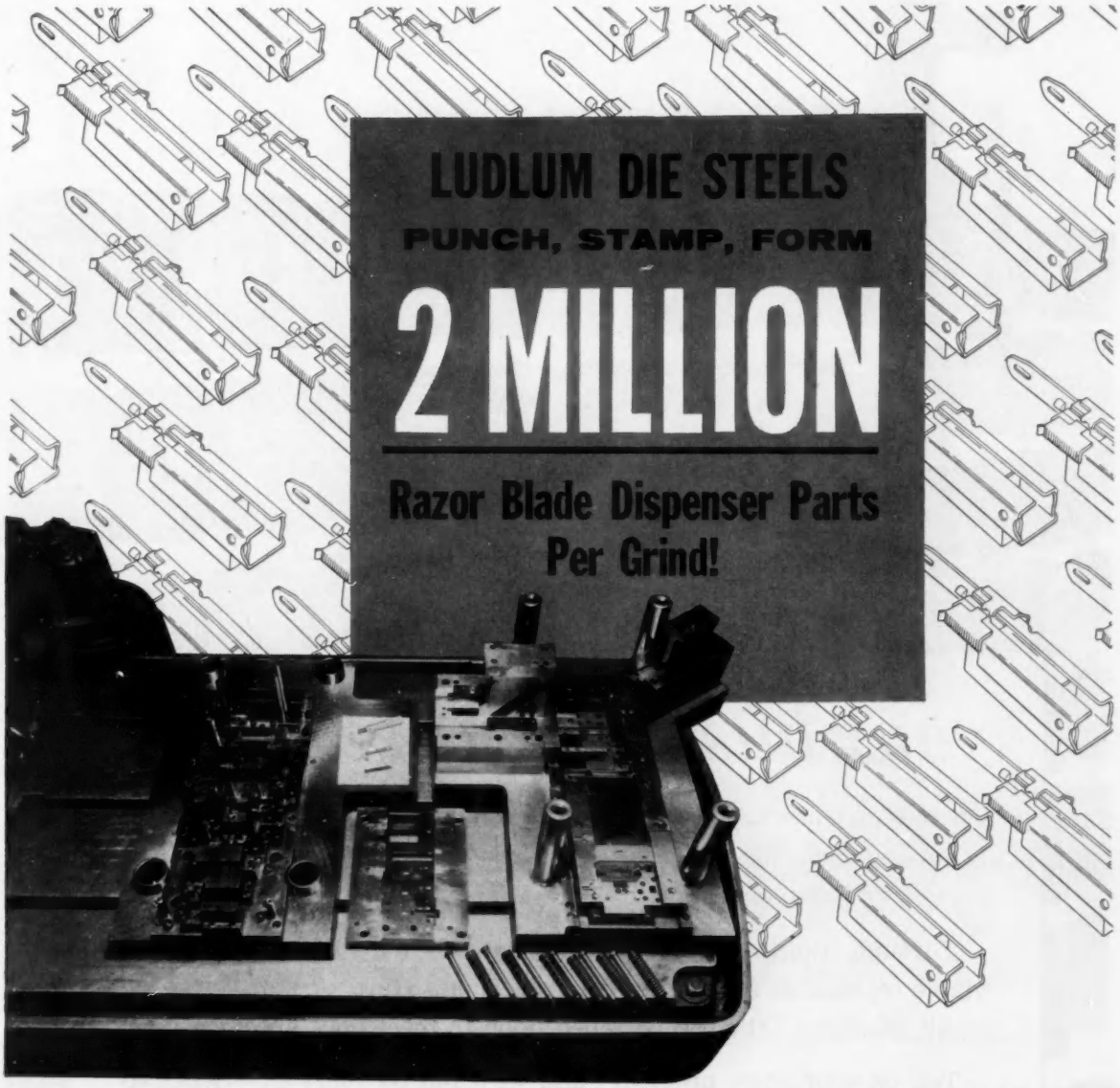
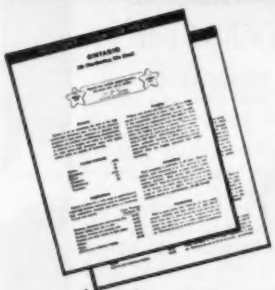


Punching, stamping and forming parts of this die are of air-hardening Ludlum ONTARIO—heat treated to 61-62 Rockwell C. Slides, frames and cams are of Ludlum DEWARD oil-hardening die steel —heat treated to 61-62 Rockwell C.

Ontario sections were pre-heated to 1250 F, then heated to 1850 F, held at 1850 F for about an hour and a half, then quenched in still air to room temperature. Finally they were drawn at 350 F for about three hours.

Deward sections (slides, frames and cams), were pre-heated to about 1200 F, then raised to 1420 F. As soon as they were uniformly heated and equalized with the furnace temperature, they were quenched in warm oil. Sections were then tempered for two hours at 325 F.

Thus, two superior Ludlum steels combine to solve an intricate production problem. You, too, may have an application that will benefit from a better selection of tool or die steels. For complete information, call your nearest A-L distributor or representative today, or write *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh, Pennsylvania.*



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DEWARD & ONTARIO BLUE SHEETS

These 4-page folders contain complete information on forging, annealing, tempering, etc., and detailed laboratory data on physical characteristics of Ludlum Deward and Ontario. *Ask for your free copy.*

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our business since 1899

There is no phase in the production of wool felt in which Western Felt is not engaged. We start with lambs wool, and end with an endless variety of parts for the many jobs that only felt can perform.

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wraps up the idea of go in one clean front-to-back sweep!

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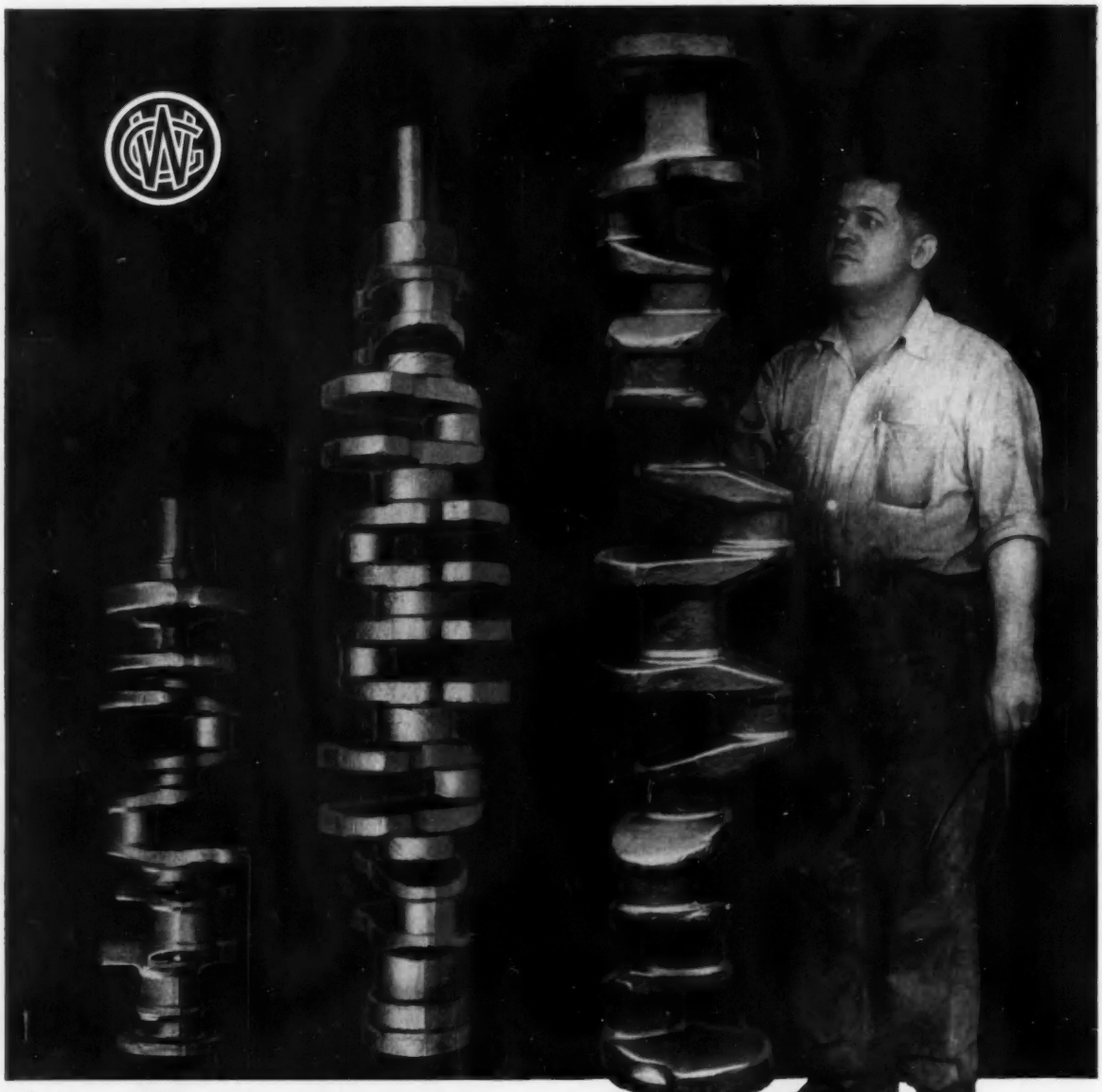

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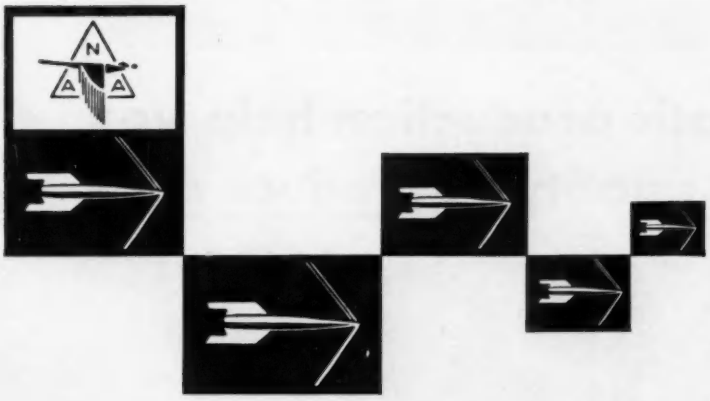

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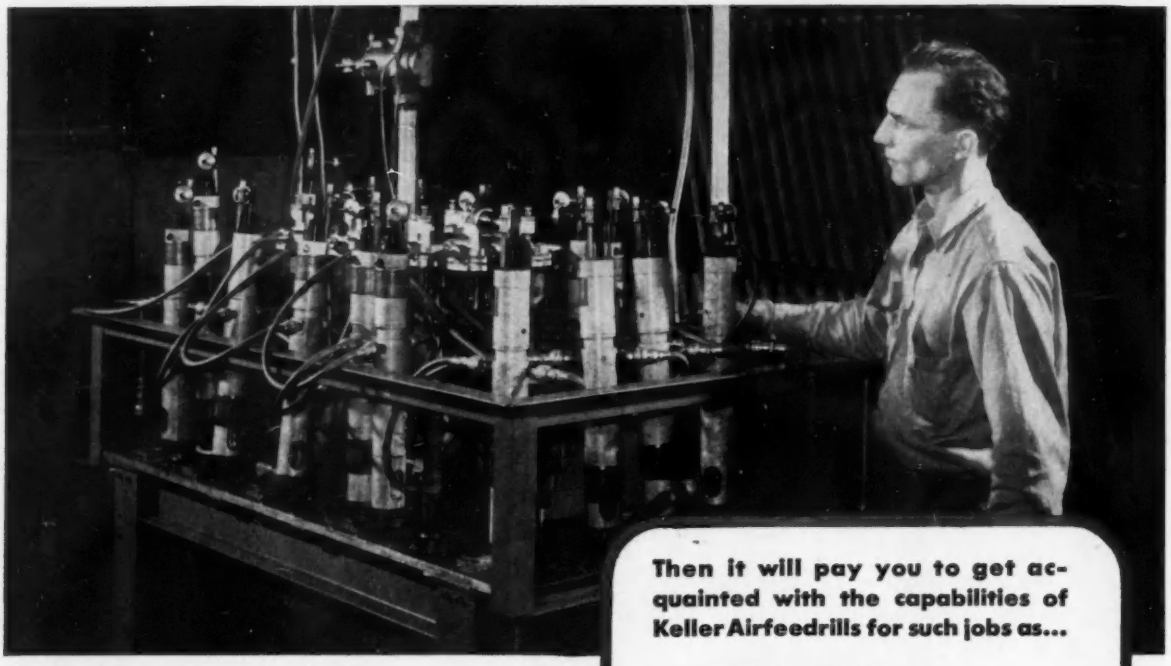

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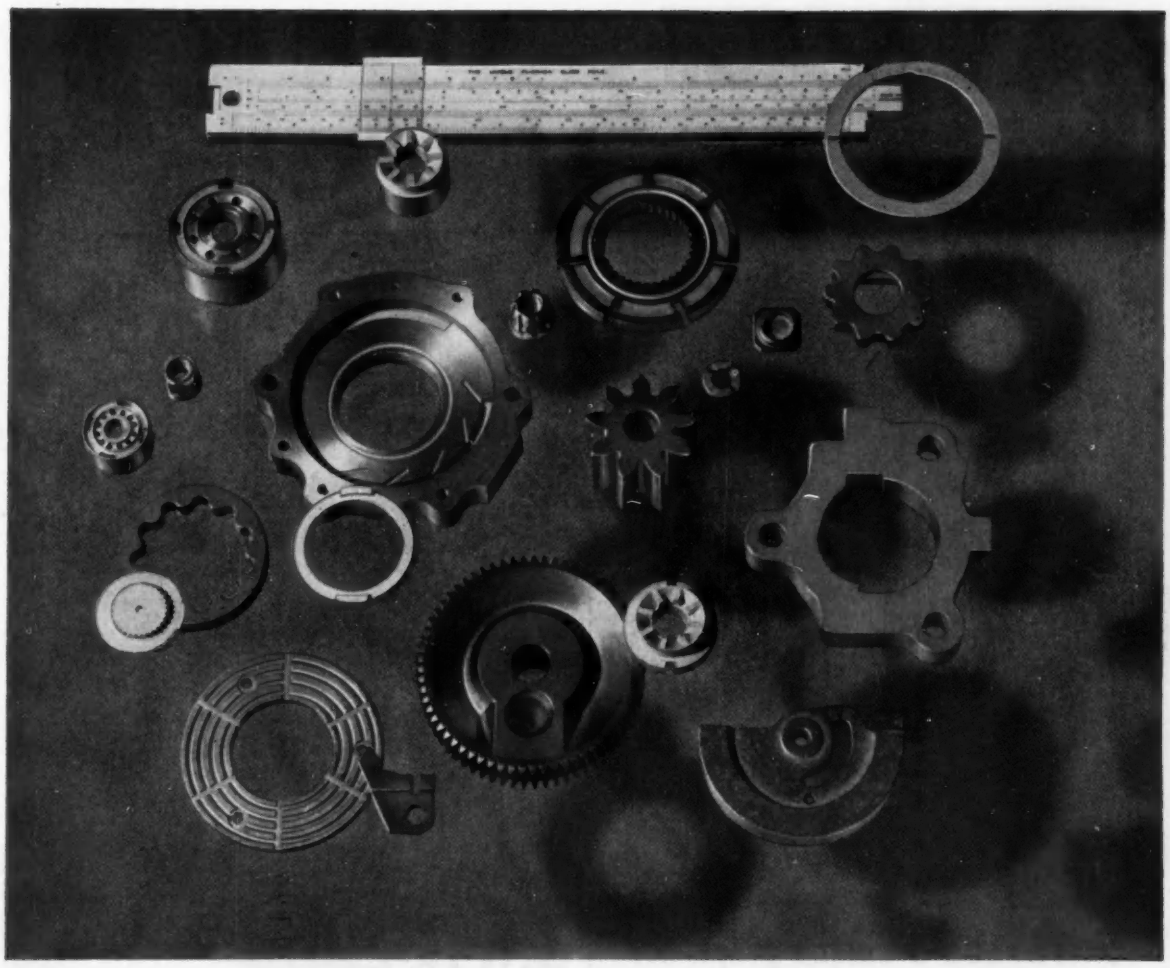

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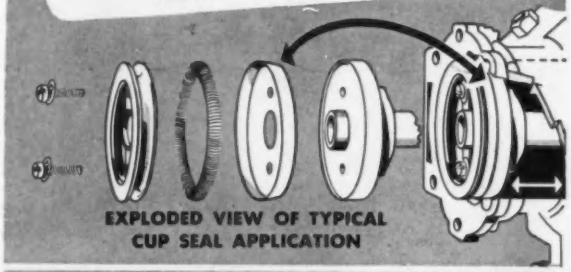

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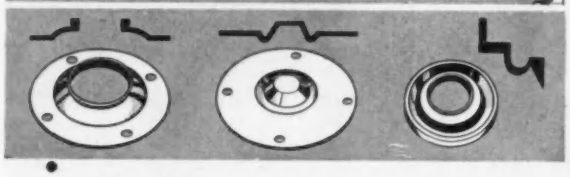

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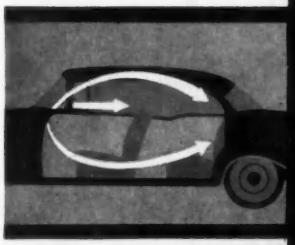

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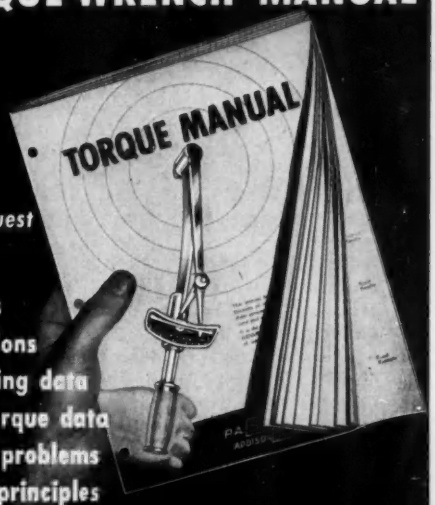

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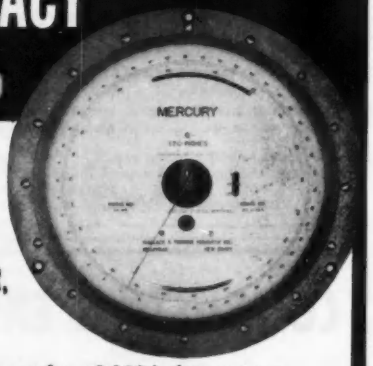

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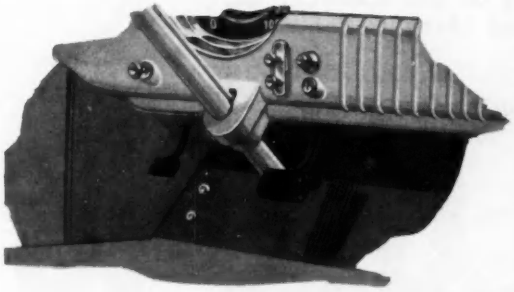

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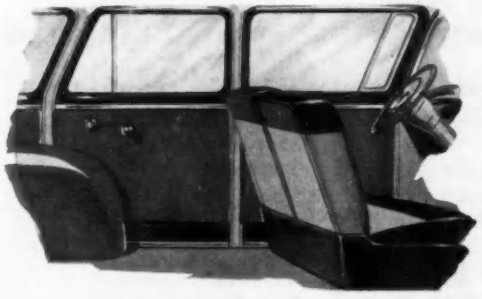

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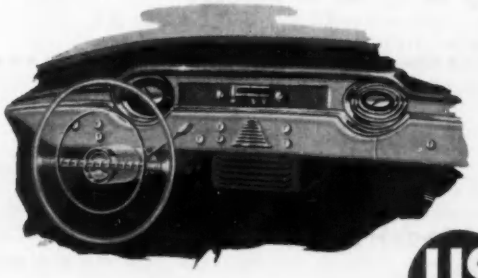

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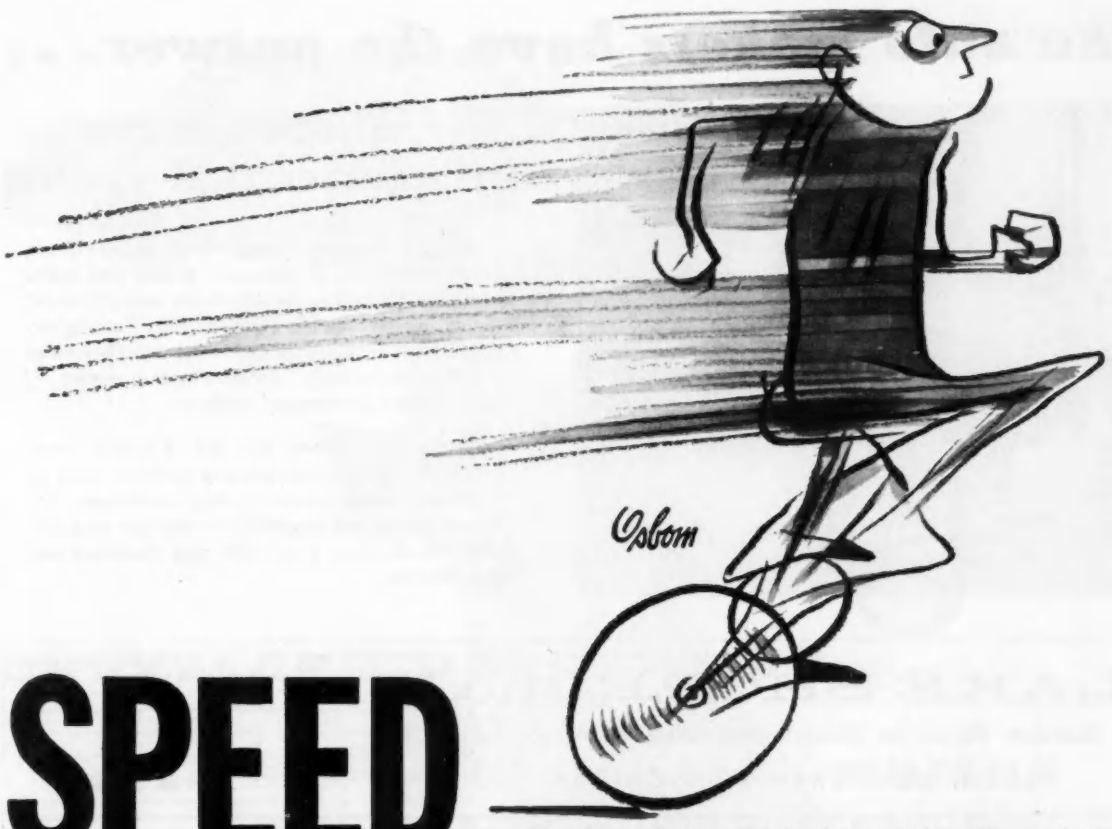

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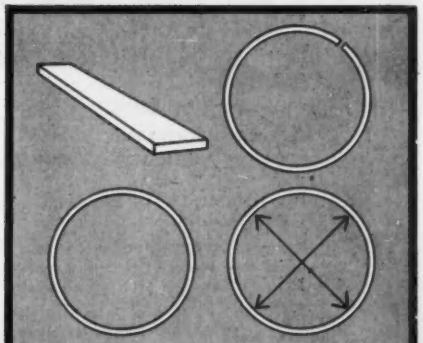

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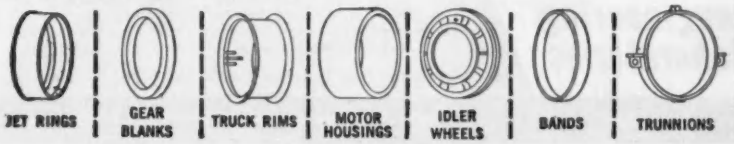

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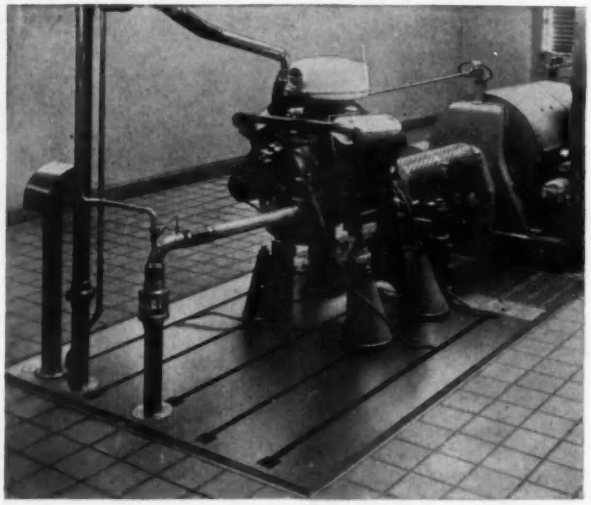

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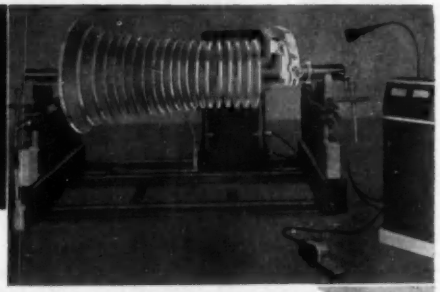

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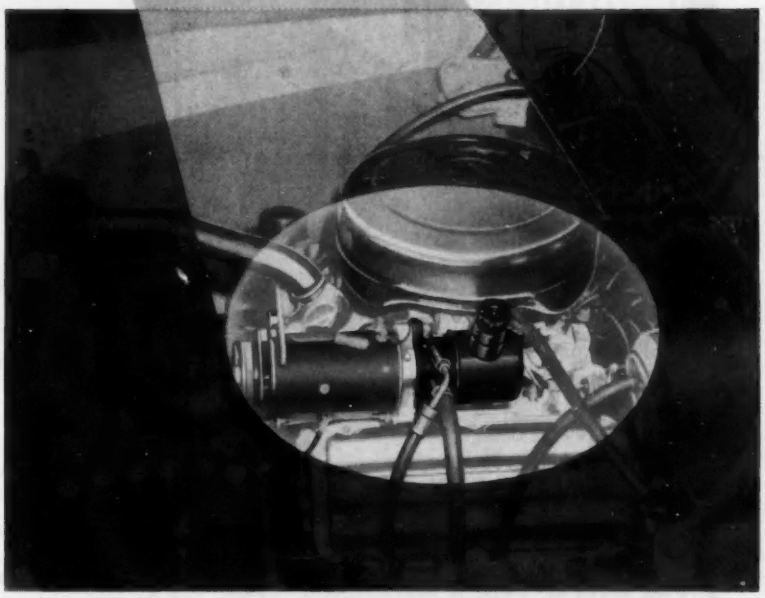

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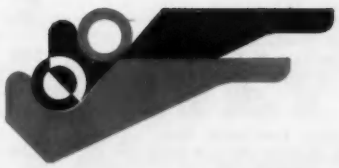

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+ INDEX TO ADVERTISERS +

A

Abbott Ball Co. 109
AC Spark Plug Div., General Motors Corp. 189
Aeroquip Corp. 133
Aetna Ball & Roller Bearing Co. Div. of Parkersburg-Aetna Corp. 214
AiResearch Manufacturing Co. 111, 178
Ajax Mfg. Co. 156
Allegheny Ludlum Steel Corp. 217
American Brakeblok Div., American Brake Shoe Co. 117
American Felt Co. 238
Auto Radiator Mfg. Co. 108
Auto Specialties Mfg. Co., Inc. 201

B

Bendix Aviation Corp.
Products Div. (General Sales) 16
Eclipse Machine Drive Div. 191
Bendix Westinghouse Automotive Air Brake Co. 159
Bethlehem Steel Co. 150
Blood Brothers Machine Co. 121
Bohn Aluminum & Brass Corp. 136, 137
Borg & Beck Div., Borg-Warner Corp. 179
Bosch, Robert 194
Bower Roller Bearing Div. 139
Bundy Tubing Co. 197, 198

C

Carter Carburetor Corp. 135
Celanese Corporation of America 205
Chicago Rawhide Mfg. Co. 6
Chrysler Corp. 219
Clark Equipment Co. 116
Cleveland Graphite Bronze Co. 206
Cleveland Pneumatic Tool Co. 200
Cleveland Steel Products 115
Cleveland Welding Div. American Machine and Foundry Co. 231
Continental Motors Corp. 106
Curtiss-Wright Corp. 176

D

Dana Corp. 152, 153
Delco-Remy Div., General Motors Corp. 154, 155
Detroit Controls Corp. 105
Detroit Gasket and Mfg. Co. 198
Detroit Steel Products Co. 131
Dewey & Almy Chemical Co., Div. of W. R. Grace & Co. 129
Douglas Aircraft Co., Inc. 2

E

Eaton Mfg. Co., Valve Div. 14
Elastic Stop Nut Corp. of America 209
Electric Auto-Lite Co. 211
Electric Wheel Co. 227
Enjay Co., Inc. 175
Evans Products Co. (Heating & Ventilating Div.) 202

F

Fabricon Products, Inc., Div. Eagle-Picher Co. 120
Fafnir Bearing Co. Inside Back Cover
Fairchild Engine & Airplane Corp., Aircraft Div. 107, 165
Fasco Industries, Inc. 130
Federal-Mogul Div. 119
Fram Corp. 216
Fuller Mfg. Co. 193

G

Gemmer Mfg. Co. 151
General Electric Co. 168
General Plate Div. Metals & Controls Corp. 12
Goodyear Tire & Rubber Co., Inc. 8, 9, 148, 149
Graton & Knight Co. 140
Great Lakes Steel Corp. 141

H

Harrison Radiator Div., General Motors Corp. 225
Harvey Machine Co. 237
Heim Co. 160
Hunter Douglas Corp. 161
Hyatt Bearings Div., General Motors Corp. 113

I

International Nickel Co., Inc. 186
International Packings Corp. 140

J

Johnson Bronze Co. 144
Johnson Products, Inc. 114

K

Kaiser Aluminum & Chemical Corp. 166, 167
Keller Tool Div. Gardner-Denver Co. 222
Kelsey-Hayes Wheel Co. 174

L

Lake Shore, Inc. 232
Leece-Neville Co. 118
Lipe Rollway Corp. 184
Lisle Corp. 110
Lockheed Aircraft Corp. 173
Long Mfg. Div., Borg-Warner Corp. 138

M

McLouth Steel Corp. 177
Magnaflux Corp. 164
Marlin-Rockwell Corp. 204
Matthews Co., James H. 234
Mechanics Universal Joint Div., Borg-Warner Corp. 147
Merrill Engineering Laboratories 232
Micromatic Hone Corp. 162
Midland Steel Products Co. 132, 169
Milford Rivet & Machine Co. 224
Milsco Mfg. Co. 228
Monroe Auto Equipment Co. 7
Moraine Products Div., General Motors Corp. 223
Morse Chain Co. 163
Muskegon Piston Ring Co. 171

N

National Motor Bearing Co., Inc. 235
National Standard Co. 208
Nelmor Mfg. Co. 207
New Departure Div., General Motors Corp. 1
North American Aviation, Inc. 190, 221

P

Packard Electric Div., General Motors Corp. 182
Palnut Co. 122
Park Drop Forge Co. 106
Parker Rust Roof Co. 188
Perfect Circle Corp. Inside Front Cover
Pontiac Motors Div., General Motors Corp. 192
Precision Rubber Products Corp. 3
Purolator Products, Inc. 145

R

Raybestos-Manhattan, Inc. Equipment Sales Div. 212, 213
Reaction Motors, Inc. 127
Republic Aviation Corp. 226
Rockford Clutch Div., Borg-Warner Corp. 124
Rohr Aircraft Corp. 158
Ross Gear & Tool Co. 5
Ryan Aeronautical Co. 199

S

Saginaw Steering Gear Div., General Motors Corp. 143
Sealed Power Corp. 125
Simmonds Aerocessories, Inc. 215
Sparta Mfg. Co. 224
Spencer Thermostat Div. Metals & Controls Corp. 128
Stackpole Carbon Co. 123
Sterling Aluminum Products, Inc. 4
Sturtevant Co., P. A. 227

T

Thompson Products, Inc. (Valve Div.) 203
Timken Detroit Axle Div. Rockwell Spring & Axle Co. 10, 11
Timken Roller Bearing Co. Outside Back Cover
The Torrington Co. (Needle Bearings) 210
Tung-Sol Electric, Inc. 142

U

United Engine and Machine Co. 180, 181
United Specialties Co. 185
U. S. Rubber Co., Naugatauk Chemicals 157, 229
Upholstery Leather Group 187

V

Veeder-Root, Inc. 170
Vellumoid Co. 224
Vickers, Inc., Division of Sperry Rand Corp. 233
Victor Mfg. & Gasket Co. 183

W

Wagner Electric Corp. 146
Waldes Kohinoor, Inc. 195
Wallace & Tiernan Products, Inc. 228
Western Felt Works 218
S. S. White Dental Mfg. Co. 134
Wisconsin Motor Corp. 126
Wyman-Gordon Co. 220

Y

Yates-American Machine Co. 112

Z

Zollner Machine Works 172

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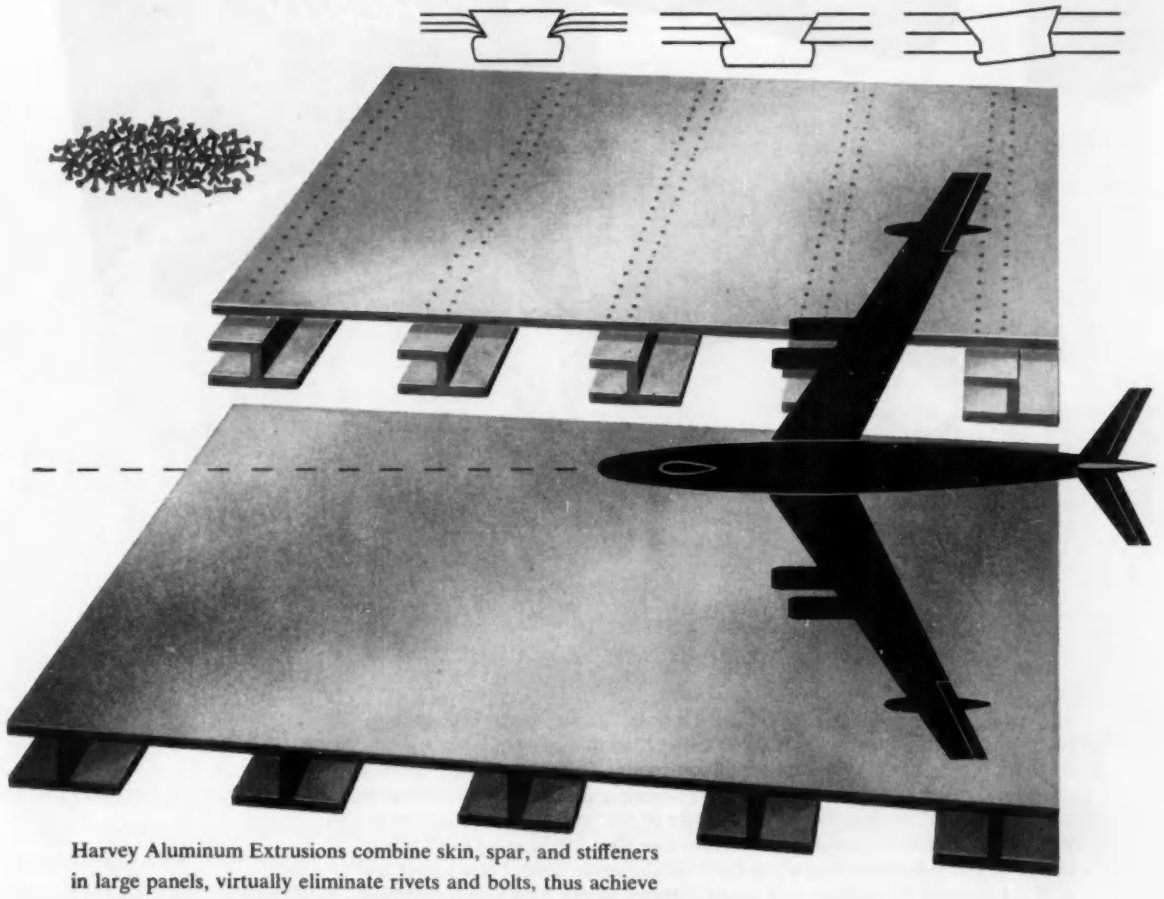

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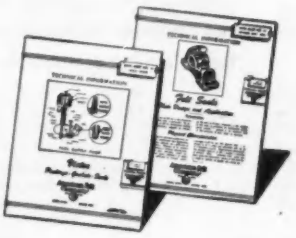

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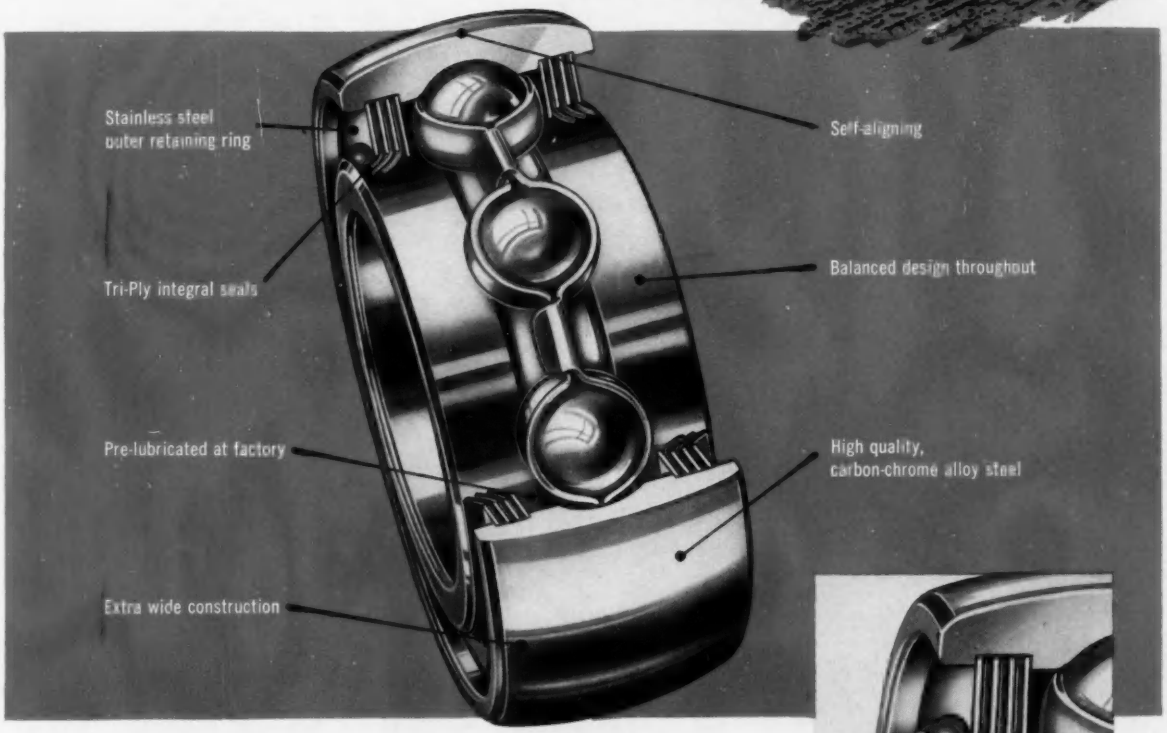

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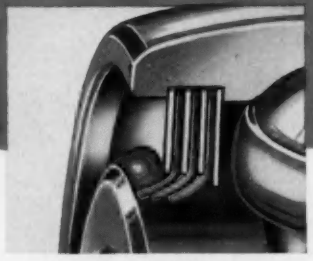

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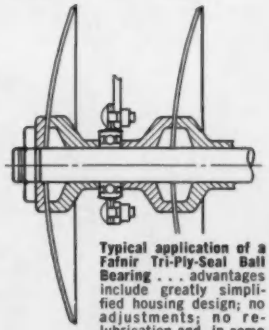

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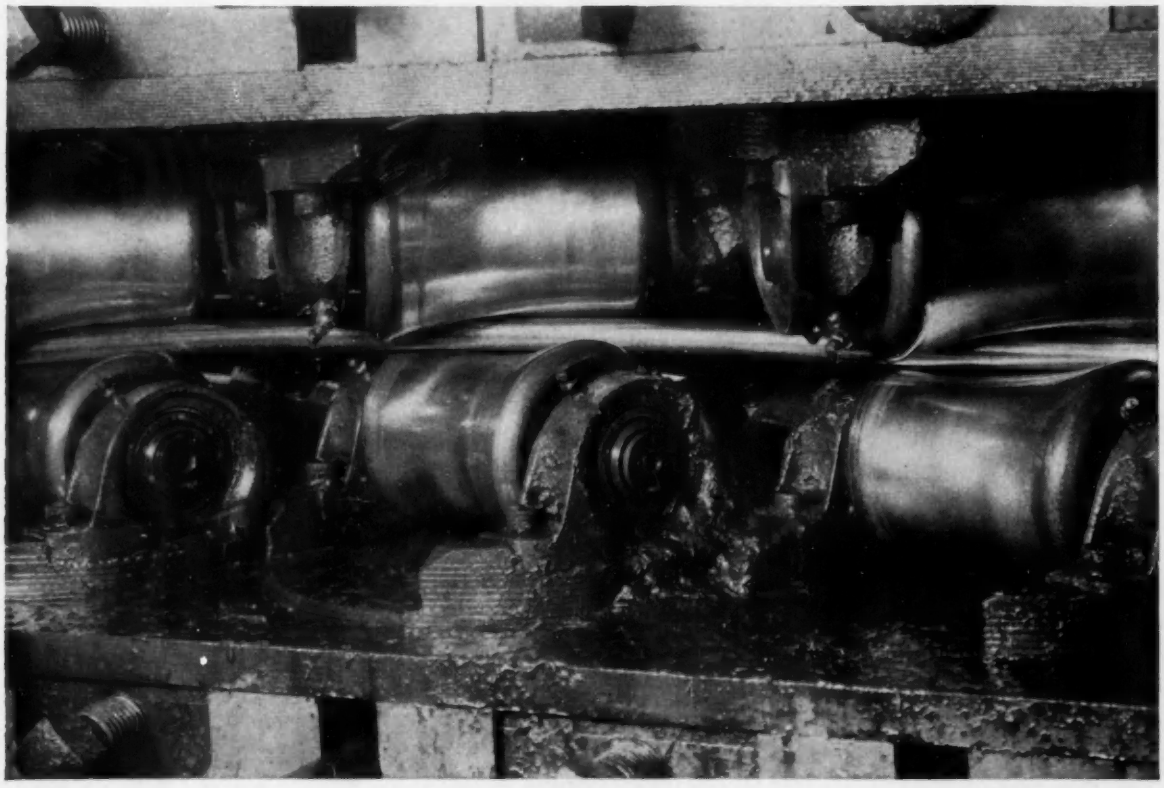

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